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ABSTRACT

A refinement in the satellite geopotential solution for a Goddard Earth Model (GEM 3) has recently been obtained. A previous satellite model, GEM 1, was based primarily upon satellite optical data on 25 satellites all with inclinations greater than 28°. The new solution includes the addition of two low inclination satellites, SAS at 3° and PEOLE at 15°, and is based upon 27 close earth satellites containing some 400,000 observations of electronic, laser, and optical data. In addition a new combination satellite/gravimetry solution (GEM 4) is derived. The new model includes 61 center of mass tracking station locations with data from GRARR, Laser, MOTS, Baker-Nunn, and NWL Tranet Doppler tracking sites.

Improvement has been obtained for the zonal coefficients of the new models and is shown by tests on the long period perturbations of the orbits. Individual zonal coefficients agree very closely among different models that contain low inclination satellites. Tests of models with surface gravity data show that the GEM 3 satellite model has significantly better agreement with the gravimetry data than the GEM 1 satellite model, and that it also has better agreement with the gravitmetry data than the 1969 SAO Standard Earth II model.

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GRAVITATIONAL FIELD MODELS GEM 3 AND 4

I. INTRODUCTION

Two Goddard Earth Models, GEM 1 and GEM 2, have previously been developed and presented in a report,(1) entitled "Gravitational Field Models for the Earth." The GEM 1 model was derived from satellite optical data and the GEM 2 model was a combined satellite and surface gravity data solution. Two additional solutions GEM 3 and GEM 4, employing a broader data base, are presented here with emphasis placed on areas of improvement. The previous report should be used as a reference since a number of the techniques developed there are the same and are not repeated in this paper. Also reference is given to a number of results from the previous solutions. Table 1 presents a brief summary of the four Goddard Earth Models for purposes of comparison.

1.1 Description of GEM 3 and GEM 4 Solutions and Data Base

A geopotential solution based upon 27 close earth satellites, including two low inclination satellites and some 400,000 observations of electronic, laser, and optical data, has recently been derived. This solution is designated as Goddard Earth Model, GEM 3. The spherical harmonic coefficients are complete to degree and order 12 as in the GEM 1 satellite solution which contained 25 satellites all with inclinations greater than 28 degrees. The addition of two satellites PEOLE (7010901) with a 15° inclination and SAS (7010701) with a 3° inclination provided improved coverage and better zonal coefficients, complete to degree 22. The new satellite solution was combined with the surface gravity data for a satellite/gravimetry geopotential solution. This solution, designated GEM 4, has spherical harmonic coefficients complete to 16 x 16 as in the GEM 2 solution. The geopotential coefficients of the GEM 3 and 4 solutions are listed in Table 2. All four models include higher degree zonal and selected satellite resonant coefficients extending to degree 22.

Geocentric station coordinates were obtained for 61 tracking stations, consisting of 19 Baker-Nunn, 23 MOTS, 4 GRARR, 3 Goddard laser, and 12 NWL Doppler tracking sites.

The data employed in the new GEM 3 satellite solution was based upon:

300 weekly orbital arcs of optical data (primarily) for the 25 satellites in Table 3A and included 120,000 observations.

48 weekly arcs of electronic laser, and optical data for 8 satellites, namely BE-B, BE-C, DI-C, DI-D, GEOS-I, GEOS-II, SAS, and PEOLE. See Table 3B for the distribution of data consisting of 292,000 observations.

100 one/two day arcs on GEOS I and II flashing light satellites, used principally to support the MOTS station coordinates.

The distribution of data on the 48 weekly arcs of electronic, laser, and additional optical data is presented in Table 3B.

The surface gravity data employed in the combination solution GEM 4 was the same as described in the GEM 2 solution.[1] Techniques and starting values for the solution, including the reference ellipsoid and gravity parameters, were the same as for GEM 1 and 2 solutions as given in the previous report.[1] The surface gravity data served as a basis for testing the satellite models and for comparison with other models. The data is described and tabulated in an appendix to this report.

II. RESULTS

1. Zonals

Zonal coefficients are compared among different solutions to examine the effect of the addition of low inclination satellite data and surface gravity data. Zonals are presented in Table 4 for the GEM 1, 2, 3 and 4 solutions, the SAO S.E. II, and the French 1971[2] zonal solution. The French solution combined the long term zonal equations of Kozai 1969 (Kozai's zonals being part of SAO S.E. II model) with corresponding equations for three low inclination satellites (SAS, PEOLE, DIAL). Zonal coefficient differences of each solution w.r.t. the French solution are presented in Table 4. The rms of the normalized coefficient differences scaled by 10^9 are given below:

	Solutions Including Effects of Low Inclination Satellites		Solutions Not Including Satellites with Inclinations $< 28°$		
Solutions	GEM 3	GEM 4	S.E. II	GEM 1	GEM 2
RMS x 10^9	9.5	7.6	16.3	22.5	9.1

In GEM 2 the satellite optical data (120,000 obs) of GEM 1 are combined with gravimetry data, while in GEM 4 the satellite electronic, laser and optical data (400,000 obs) of GEM 3 are combined with the gravimetry data.

The agreement of GEM 3 and the French zonals with an rms value of 9.5 x 10^{-9} for the zonal differences is quite remarkable. This is particularly so considering that the GEM 3 zonal recovery is based upon short term zonal effects on weekly orbital arcs, while those of the French are based upon long term zonal effects. The rms of 7.6 x 10^{-9} between GEM 4 and the French zonals is approaching the accuracy estimates as given by their standard deviations from each of the solutions. An rms of the zonal standard deviations from the GEM 4 solution is 5 x 10^{-9} and that for the French[2], as obtained from their standard deviations, is 4.5 x 10^{-9} for the normalized coefficients. Satellite test results using these solutions are presented in Section 4 for long term zonal effects.

Geoid height zonal profiles between the French and GEM 4 solutions showed a maximum difference of 0.8 meters. An estimated rms of height differences was less than 0.3 of a meter. The GEM 2 and SAO S.E. II geoid height profiles, presented in Figures 2 and 3 of the previous report,[1] show a maximum difference of about 1.5 meters.

2. Station Height Above Geoid vs Survey and Ellipsoid Scale

Station height above the geoid from the dynamic solution, GEM 4, is compared with the mean sea level height (MSLH) from survey and plotted in Figure 1. Geocentric station coordinates were determined for 61 stations. The geodetic station coordinates, referenced to the ellipsoid of a_e = 6378155 m. and 1/f = 298.255, and geoid data are given in Table 5. As in the previous GEM 2 solution (Figure 6 of ref. 1), station heights from GEM 4 indicate an average equatorial radius for the earth of about a_e = 6378145 m. In the previous results only 33 of the 46 stations were used, since 13 Baker-Nunn stations were excluded because of a problem that existed in parallactic refraction correction. This problem has been remedied for the present results.

A value of $\Delta\bar{g}_0 = 3.5$ mgal, adjustment to the reference value of mean gravity, was obtained from use of the surface gravity data as in the previous GEM 2 solution. The new value of $\Delta\bar{g}_0$ (see the analysis on page 12 of ref. 1) corresponds to a scale of a_e = 6378141 m. The previous result of $\Delta\bar{g}_0 = 3.3$ for the GEM 2 solution corresponded to a scale of a_e = 6378142 m. The results of a_e from both the station data and surface gravity data are reasonably consistent. Again as in reference 1, the above results are based upon a fixed reference value of GM = 398601.3 km^3/sec^2.

3. Comparison of Solutions with 5° x 5° Mean Gravity Anomalies

A statistical procedure was presented by Kaula[3] for testing satellite data solutions with gravimetry data and for comparing combined satellite and gravimetric solutions. The following quantities are defined for the 5° x 5° mean gravity anomalies and used in Table 6 for comparing solutions:

$E\left((G_T - G_S)^2\right)$ = mean square difference between the terrestrial anomaly G_T and the computed anomaly G_S from the solution

$E\left(G_T{}^2\right)$ = mean square of the terrestrial sample anomalies

$E\left(G_S{}^2\right)$ = mean square of anomaly computed from the solution

$E(G_T G_S)$ = estimate of the variance of G_H, the true contribution to G_S

$E(\epsilon_T{}^2)$ = mean square value of terrestrial anomaly error

$E\left(\delta_g{}^2\right)$ = mean square value of neglected higher degree terms in the G_S set (Omission error)

$E(\epsilon_S{}^2)$ = mean square error in the solution G_S (Commission error)

For a given argument Q, the preceding quantities E(Q) are computed from

$$E(Q) = \frac{\sum_i Q_i \cos \phi_i}{\sum_i \cos \phi_i}$$

where the subscript i corresponds to a 5° x 5° block at latitude ϕ_i, and $\cos \phi_i$ provides for equal area contribution over the earth.

Formulas for the mean square errors of ϵ_T and ϵ_S and the neglected higher degree terms δ_g are

$$E(\epsilon_T{}^2) = E\left[\frac{E(G_T{}^2)}{n}\right],$$

$$E(\epsilon_S{}^2) = E(G_S{}^2) - E(G_H{}^2),$$

$$E(\delta_g{}^2) = E\left((G_T - G_S)^2\right) - E(\epsilon_T{}^2) - E(\epsilon_S{}^2).$$

where n is the number of 1° x 1° anomalies in a 5° x 5° block.

The gravimetry data, employed in the comparisons, consisted of 1707 blocks of 5° x 5° mean gravity anomalies (G_T) out of a possible 2592 world wide blocks. The data is listed in the appendix with a description of the reference system and source of data. The 5° x 5° means were based upon approximately 21,000 1° x 1° mean free-air gravity anomalies. Each 5° x 5° mean (G_T) was formed from a straight average of the number, n, of 1° x 1° means that existed in the 5° x 5° block. The content n for the 5° x 5° blocks was quite uneven. Samples of the 5° x 5° mean anomalies (G_T) have been selected for blocks that contain at least 5, 10, 15, 20, and 25 points (n) of the original 1° x 1° mean gravity anomalies. The following table is presented for description of the 5 samples and one additional sample containing all of the 5° x 5° means.

Sample No.	$n \geq$	Number of 5° x 5° Blocks	$E(G_T^2)$ mgal^2	% of Original 1° x 1° Anomalies
1	1	1707	660	100
2	5	1284	435	96
3	10	881	429	82
4	15	624	417	67
5	20	434	367	51
6	25	233	374	34

The mean square terrestrial 5° x 5° anomaly $E(G_T^2)$ is noted to be quite large in the first sample as compared to the remaining samples where $E(G_T^2)$ shows a gradual decrease. The large value (660) may be expected since the $E(G_T^2)$ for the 1° x 1° anomalies is 33^2 (~1000) mgal^2 and contain higher frequencies. Thus fewer points (n) used in forming a 5° x 5° mean anomaly will lack the effect of the ideal smoothing (i.e. with 25 1° x 1° means, n = 25) and tend to give large estimates for the 5° x 5° mean anomaly as shown in the table. Inspection of the 1707 blocks revealed approximately 34 5° x 5° anomalies for which $70 < |G_T| \leq 219$ mgal and which were formed from one or just a few points of the 1° x 1° original data. After these points were removed for the case of $n \geq 1$, $E(G_T^2) = 453$ mgal^2. The sample of $n \geq 1$ was not used in the following comparisons.

The comparisons of the terrestrial 5° x 5° gravity anomaly, (G_T), with that computed (G_S) from different solutions are summarized in the table below. Results for the complete set of statistics, defined by Kaula, are given in Table 6. The geopotential solutions used are reviewed as follows:

GEM 1 (12 x 12) - optical satellite data solution (12 x 12 complete in spherical harmonics)

GEM 3 (12 x 12) - optical plus electronic satellite data solution

GEM 4 (16 x 16) - combined satellite (GEM 3) and surface gravity data solution

20 x 20 - same as GEM 4 but with surface gravity complete to 20 x 20

20 x 20 W2 - same as 20 x 20 but with the surface gravity given twice the weight

SAO S.E. II (16 x 16) - SAO 1969 Standard Earth II model, a combination of satellite optical data and surface gravity data consisting of 935 (equal area 300 nm square) blocks of mean terrestrial gravity anomalies.

The above solutions all contain selected higher degree zonal and satellite resonant coefficients extending to degree 22.

Comparison of 5° x 5° Mean Gravity Anomalies Obtained from Potential Coefficients (G_S) and Terrestrial Data (G_T) (Summary of Table 6)

Mean Square of Differences $\left(G_T - G_S\right)$, $E\left(\left(G_T - G_S\right)^2\right)$ mgals^2

Solutions	$n \geq 5$ 1284 (Blocks)	$n \geq 10$ 881	$n \geq 15$ 624	$n \geq 20$ 434	$n = 25$ 233
GEM 1 (12 x 12)	261	242	249	216	213
SAO S.E. II (16 x 16)	261	241	242	200	224
GEM 3 (12 x 12)	252	231	238	208	204
GEM 4 (16 x 16)	208	186	188	164	160
20 x 20	179	153	152	130	125
20 x 20 W2	172	147	145	123	119
$E\left(G_T{}^2\right)$	435	429	417	367	374
$E\left(\epsilon_T{}^2\right)$	55	36	28	23	23

Variance of the Error ϵ_S of Commission in the Solution, $E\left(\epsilon_S{}^2\right)$ mgal^2

	$n \geq 5$	$n \geq 10$	$n \geq 15$	$n \geq 20$	$n = 25$
GEM 1 (12 x 12)	24	23	26	30	22
SAO S.E. II (16 x 16)	36	39	43	38	41
GEM 3 (12 x 12)	21	18	21	26	18
GEM 4 (16 x 16)	14	8	6	12	4

Variance of Error of Omission δ_g for the Solution, $E(\delta_g{}^2)$ mgal^2

	$n \geq 5$	$n \geq 10$	$n \geq 15$	$n \geq 20$	$n = 25$
GEM 3 (12 x 12)	176	177	190	159	163
GEM 4 (16 x 16)	137	143	154	130	133
20 x 20 W2	104	106	120	101	94

The statistical results in the table are in general quite good. In each of the solutions, the sample variances $E((G_T - G_S)^2)$ generally show better results for the samples where the 5° x 5° mean gravity anomalies are based upon a more complete set of points (n) of the 1° x 1° means. This may be expected for the solutions where the surface gravity data is used, since the 5° x 5° mean anomalies are weighted proportionately to the number of points n (n + 1 is actually used). The satellite solutions, however, also show the same trend of agreement. The variances show the best agreement for the 20 x 20 field W2, where the surface gravity data is given greater weight by a factor of 2. The increased weighting contributes a reduction of 6 to 7 mgal^2 for the associated samples w.r.t. 20 x 20 field which has the normal weight. However the increase in the dimension to degree and order 20 provides a larger reduction of 29 to 36 mgal^2 w.r.t. the GEM 4 field (16 x 16). And in turn it has a reduction on the average of about 50 mgal^2 over GEM 3 (12 x 12) satellite solution. The GEM 3 satellite solution (electronic plus optical data) is seen to agree better with the gravity data than GEM 1 (optical data only) satellite solution in every sample with a reduction in the variances of from 8 to 11 mgal^2.

The SAO S.E. II solution, based upon satellite optical and surface gravity data of 300 nm equal area squares, have variances which are a little larger than the GEM 3 satellite solution. This result is not expected, since surface gravity data was used in the S.E. II and not used in the GEM 3 satellite solution.

An estimate for the accuracy of the solution is given in the table by the variances $E(\epsilon_S{}^2)$. These error estimates presented for the GEM 1, GEM 3, and GEM 4 solutions decrease respectively as may be expected from the above agreement with the surface gravity data as indicated by $E((G_T - G_S)^2)$. The error estimates for the S.E. II solution are larger than the other solutions. The error estimates for each solution are relatively consistent on each of the 5 samples.

Since 5° x 5° mean gravity anomalies covering the earth contain information that may be expected to correspond to a geopotential solution with spherical harmonics complete to degree and order 36, the neglected portion δ_g of the solutions should be expected to contain much remaining information. The information that remains to be recovered in the data as given by the variances, $E(\delta_g{}^2)$, is relatively consistent on each of the samples for the GEM 3, GEM 4, and the

20 x 20 W2 solutions which are presented in the table. The sample variances for each of the solutions, where

$$\begin{matrix}\text{Total} \\ \text{Misclosure}\end{matrix} = \begin{matrix}\text{Data} \\ \text{Error}\end{matrix} + \begin{matrix}\text{Solution} \\ \text{Error}\end{matrix} + \begin{matrix}\text{Omission} \\ \text{Error}\end{matrix}$$

$$E\left((G_T - G_S)^2\right) = E\left(\epsilon_T{}^2\right) + E\left(\epsilon_S{}^2\right) + E\left(\delta_g{}^2\right)$$

show that the larger part of the misclosure lies in the omitted part of the expected solution of the terrestrial data (36 x 36), namely $E\left(\delta_g{}^2\right)$. The 20 x 20 W2 field shows approximately 100 mgal^2 that remains to be recovered from the data, while the GEM 3 satellite solution shows this value as large as 175 mgal^2 and GEM 4 solution shows 137 mgal^2.

The degree variances of the gravity anomalies are presented in Table 7 for the different solutions (for GEM 1 see Table 6 of ref. 1). The sum of the degree variances of the gravity anomalies should be equal to $E\left(G_s{}^2\right)$ over the entire Earth. Values of $E\left(G_s{}^2\right)$ are given below for the case of $n \geq 5$ (1284 blocks) and for 2592 5° x 5° blocks covering the entire earth.

Solution	$E\left(G_s{}^2\right)$ $n \geq 5$ 1284 Blocks	$E\left(G_s{}^2\right)$ 2592 Blocks	Sum of Degree Variances (n = 2 to 22)
GEM 1 (12 x 12)	222	186	186
GEM 3 (12 x 12)	225	191	188
GEM 4 (16 x 16)	257	240	234
SAO S.E. II (16 x 16)	248	219	216

The results of $E\left(G_s{}^2\right)$ for the entire earth show good agreement with the sum of the degree variances. The values of $E\left(G_s{}^2\right)$ for the sample anomalies corresponding to the case of $n \geq 5$ all are larger than the other two cases. Since this is true for the satellite solutions as well, it indicates that the areas not sampled, principally in the South Pacific, have smaller gravity anomalies at least as represented by the spherical harmonic solutions.

4. Satellite Test Results

Two geopotential solutions have been tested on all 23 of the satellites (Table 3A) with optical data. Results of the rms of observation residuals are listed in

Table 8 for a weekly arc on each of the satellites. Similar rms values, given in Table 3A, are based upon the starting solution. Solutions for which the results were obtained are the GEM 1 and the S.E. II models. The average rms for all the satellites for each model is as follows:

	SAO S.E. II	GEM 1
Average rms	3.42"	2.75"

These results are somewhat expected since the SAO S.E. II solution also had to satisfy surface gravity data. On the other hand, the GEM 1 satellite solution satisfied the GSFC surface gravity data almost as well as the SAO S.E. II solution (see Table 6).

A result is given below for the GEM 3 and SAO S.E. II solutions employing ISAGEX French laser data of 1700 range observations, taken on the Haute Provence site for a weekly arc of the GEOS-I satellite (710219/26). This data was not used in either solution, and the rms of the laser range residuals are:

	S.E. II	GEM 3	
rms	8 meters	4 meters	1700 range obs

Zonal solutions were tested by Carl A. Wagner[4] on 21 satellites, including the low inclination satellites of SAS and PEOLE, for their long term zonal effects on mean elements. Wagner uses as a test criteria the weighted rms of the mean element residuals of each solution. These residuals are to be used as a relative measure of testing and are listed here with other solutions (not included in ref. 4) for comparison as follows:

Solution	rms
SAO S.E. II	5.49
GEM 2	4.80
GEM 1	3.62
French 71	3.28
GEM 3	2.92
GEM 4	2.89
Wagner	1.50

Only about half of the 21 satellites used in Wagner's solution are contained in the other models.

The GEM 3 satellite solution and the GEM 4 satellite/gravimetric solution compare well in this test. Considering the GEM 3 solution was based upon satellite weekly orbital arcs and the French 71 solution was based upon satellite long term zonal effects, it verifies that good zonal recovery may be achieved from short term zonal effects. The SAO S.E. II, GEM 1 and GEM 2 solutions do not compare as well in these tests because they do not contain the effects of low inclination satellites. Wagner's result is expected to have the lowest rms since his solution is based entirely upon the test data.

III. SUMMARY AND CONCLUSIONS

The new satellite solution GEM 3 including the addition of two low inclination satellites and employing some 400,000 observations of electronic, laser and optical data provides for a refinement over the GEM 1 satellite solution. GEM 1 was based upon 25 satellites consisting primarily of optical data. The test results of GEM 3 with gravimetric data and long term satellite zonal effects show improvement over the GEM 1 solution and also that of the SAO 1969 S.E. II model. The latter two models contained satellites all with inclinations greater than 28°. A test with GEOS-I ISAGEX French laser data, independent of the solutions, also showed better results for the GEM 3 than the S.E. II model.

The GEM 4 solution combined the GEM 3 satellite data with the gravimetric data and provided a geopotential model complete to degree and order 16 with zonals and selected satellite resonant coefficients extending to degree 22. The solution included 61 center of mass tracking station locations and an adjustment ($\Delta \bar{g}_0$) to the reference value of mean gravity. Analysis of the heights of these stations above the GEM 4 geoid with the mean sea level heights from survey indicated a mean earth ellipsoid radius of about a_e = 6378145 meters, while analysis of $\Delta \bar{g}_0$ (3.5 mgal) indicated a_e = 6378141 meters. The two results are fairly consistent and are based upon the reference value of GM = 398601.3 km^3/sec^2.

The analysis of the gravity data in terms of 5° x 5° mean gravity anomalies indicated that additional information remains to be recovered from the data. A GSFC combination satellite/gravimetric solution complete to degree and order 20 showed approximately 100 $mgal^2$ remained to be recovered for the 5° x 5° mean terrestrial anomaly.

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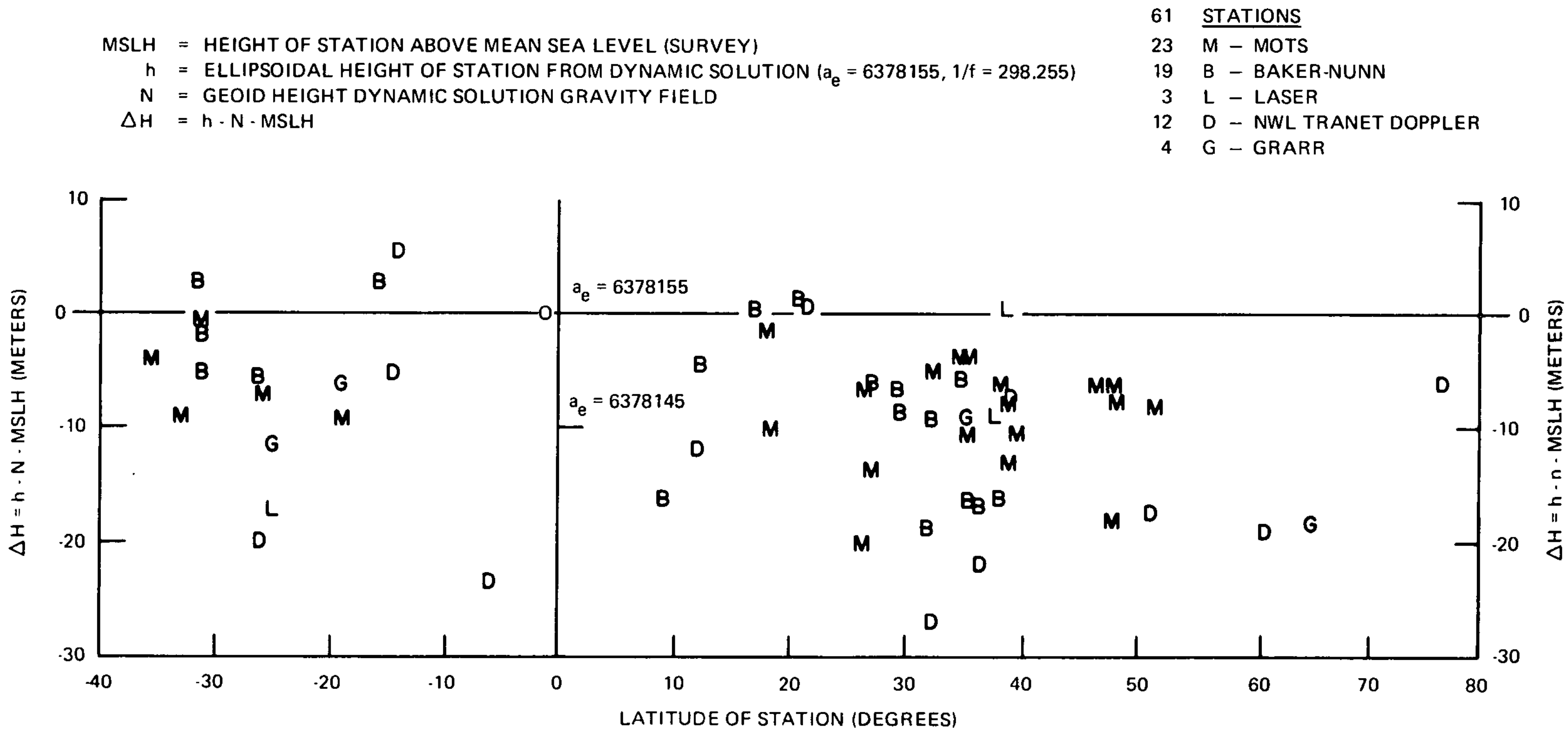

Figure 1. Dynamic Station Height Above Geoid vs. Survey

Table 1

Comparison of Goddard Earth Models (GEM)
(Geopotential Solutions)

Geopotential Solution	Completeness of Spher. Harm. Field*	Satellite Data	Gravimetry Data
GEM 1	12 x 12 Satellite	120,000 Optical Obs. on 25 Satellites	
GEM 2	16 x 16 Combined	GEM 1 Data	1707 5° x 5° Mean Gravity Anomalies
GEM 3	12 x 12 Satellite	400,000 Optical and Electronic Obs. on 27 Satellites	
GEM 4	16 x 16 Combined	GEM 3 Data	1707 5° x 5° Mean Gravity Anomalies

*All solutions included higher degree zonal and satellite resonant coefficients extending to degree 22. (GEM 1 and 2 excluded the zonal coefficient of degree 22.)

- 61 Center of mass tracking station locations included in the GEM 3 and 4 models.

  46 stations included in the GEM 1 and 2 models

- Two low inclination satellites SAS 3°, PEOLE 15° included in GEM 3 and 4.

  25 satellites in previous GEM 1 and 2 solutions all have inclination >28°.

- 5° x 5° mean gravity anomalies based upon:

  19,000 1° x 1° Anomalies from ACIC

  2,000 1° x 1° Anomalies from other sources

Table 2

GSFC Geopotential Solutions (Normalized Coefficients x 10^6) 1

	L	M	GEM 4	GEM 3
C	2	0	-484.1690	-484.1718
S	2	0	0.0	0.0
C	3	0	0.9570	0.9577
S	3	0	0.0	0.0
C	4	0	0.5412	0.5470
S	4	0	0.0	0.0
C	5	0	0.0692	0.0681
S	5	0	0.0	0.0
C	6	0	-0.1528	-0.1617
S	6	0	0.0	0.0
C	7	0	0.0910	0.0924
S	7	0	0.0	0.0
C	8	0	0.0515	0.0619
S	8	0	0.0	0.0
C	9	0	0.0312	0.0302
S	9	0	0.0	0.0
C	10	0	0.0502	0.0400
S	10	0	0.0	0.0
C	11	0	-0.0561	-0.0560
S	11	0	0.0	0.0
C	12	0	0.0389	0.0463
S	12	0	0.0	0.0
C	13	0	0.0477	0.0490
S	13	0	0.0	0.0
C	14	0	-0.0266	-0.0296
S	14	0	0.0	0.0
C	15	0	-0.0050	-0.0073
S	15	0	0.0	0.0
C	16	0	-0.0093	-0.0116
S	16	0	0.0	0.0
C	17	0	0.0174	0.0196
S	17	0	0.0	0.0
C	18	0	0.0113	0.0163
S	18	0	0.0	0.0
C	19	0	0.0090	0.0077
S	19	0	0.0	0.0
C	20	0	0.0090	0.0032
S	20	0	0.0	0.0

	L	M	GEM 4	GEM 3
C	21	0	-0.0076	-0.0075
S	21	0	0.0	0.0
C	22	0	-0.0038	-0.0015
S	22	0	0.0	0.0
C	2	1	-0.0078	-0.0078
S	2	1	-0.0004	-0.0068
C	3	1	2.0164	2.0174
S	3	1	0.2498	0.2508
C	4	1	-0.5330	-0.5322
S	4	1	-0.4614	-0.4444
C	5	1	-0.0741	-0.0687
S	5	1	-0.0786	-0.0817
C	6	1	-0.0905	-0.0889
S	6	1	0.0084	-0.0209
C	7	1	0.2553	0.2524
S	7	1	0.1334	0.1309
C	8	1	0.0297	0.0276
S	8	1	0.0578	0.0944
C	9	1	0.1536	0.1609
S	9	1	0.0088	0.0022
C	10	1	0.0757	0.0761
S	10	1	-0.1436	-0.1798
C	11	1	-0.0199	-0.0158
S	11	1	0.0371	0.0326
C	12	1	-0.0592	-0.0656
S	12	1	-0.0466	-0.0152
C	13	1	0.0183	0.0
S	13	1	-0.0753	0.0
C	14	1	-0.0453	-0.0150
S	14	1	0.0371	0.0053
C	15	1	0.1043	0.0
S	15	1	0.0419	0.0
C	16	1	-0.0314	0.0
S	16	1	0.0082	0.0
C	2	2	2.4237	2.4255
S	2	2	-1.3895	-1.3856
C	3	2	0.9164	0.9141
S	3	2	-0.6322	-0.6240

	L	M	GEM 4	GEM 3
C	4	2	0.3511	0.3542
S	4	2	0.6652	0.6637
C	5	2	0.6620	0.6570
S	5	2	-0.3145	-0.3188
C	6	2	0.0679	0.0675
S	6	2	-0.3795	-0.3697
C	7	2	0.3395	0.3355
S	7	2	0.0748	0.0795
C	8	2	0.0511	0.0482
S	8	2	0.0739	0.0659
C	9	2	0.0534	0.0236
S	9	2	-0.0171	-0.0176
C	10	2	-0.0457	-0.0471
S	10	2	-0.0667	-0.0408
C	11	2	0.0158	0.0363
S	11	2	-0.1250	-0.1130
C	12	2	-0.0449	-0.0408
S	12	2	0.0532	0.0373
C	13	2	0.0194	0.0
S	13	2	-0.1477	0.0
C	14	2	-0.0376	0.0
S	14	2	0.1169	0.0
C	15	2	0.0006	0.0
S	15	2	-0.1010	0.0
C	16	2	0.0108	0.0
S	16	2	0.0217	0.0
C	3	3	0.7063	0.7203
S	3	3	1.4231	1.4197
C	4	3	0.9713	0.9755
S	4	3	-0.2187	-0.2196
C	5	3	-0.4701	-0.4674
S	5	3	-0.2566	-0.2778
C	6	3	0.0169	0.0226
S	6	3	-0.0127	-0.0259
C	7	3	0.2558	0.2655
S	7	3	-0.2281	-0.2224
C	8	3	-0.0262	-0.0238
S	8	3	-0.0809	-0.0831

	L	M	GEM 4	GEM 3
C	9	3	-0.1760	-0.1493
S	9	3	-0.1049	-0.1518
C	10	3	-0.0483	-0.0409
S	10	3	-0.0976	-0.1206
C	11	3	-0.0205	-0.0111
S	11	3	-0.0887	-0.1193
C	12	3	0.1389	0.1120
S	12	3	0.0429	0.0859
C	13	3	-0.0335	0.0
S	13	3	0.0301	0.0
C	14	3	0.0386	0.0
S	14	3	-0.0157	0.0
C	15	3	0.0150	0.0
S	15	3	0.0552	0.0
C	16	3	0.0306	0.0
S	16	3	-0.0160	0.0
C	4	4	-0.1811	-0.1815
S	4	4	0.3153	0.3123
C	5	4	-0.3167	-0.3213
S	5	4	0.0321	0.0253
C	6	4	-0.1065	-0.1094
S	6	4	-0.4601	-0.4576
C	7	4	-0.2939	-0.3131
S	7	4	-0.1064	-0.0869
C	8	4	-0.2480	-0.2531
S	8	4	0.0466	0.0693
C	9	4	0.0212	0.0026
S	9	4	0.0139	0.0338
C	10	4	-0.0934	-0.0981
S	10	4	-0.1177	-0.1101
C	11	4	0.0027	0.0191
S	11	4	-0.0937	-0.0770
C	12	4	-0.0423	-0.0195
S	12	4	-0.0168	-0.0131
C	13	4	-0.0543	0.0
S	13	4	-0.0737	0.0
C	14	4	0.0346	0.0
S	14	4	0.0064	0.0

	L	M	GEM 4	GEM 3
C	15	4	0.0099	0.0
S	15	4	-0.0254	0.0
C	16	4	0.0308	0.0
S	16	4	0.0733	0.0
C	5	5	0.1760	0.1481
S	5	5	-0.6845	-0.6782
C	6	5	-0.2964	-0.3033
S	6	5	-0.5115	-0.5051
C	7	5	0.0035	-0.0102
S	7	5	0.0321	0.0561
C	8	5	-0.0884	-0.0957
S	8	5	0.0846	0.0858
C	9	5	-0.0326	-0.0203
S	9	5	-0.0548	-0.0678
C	10	5	-0.0682	-0.1102
S	10	5	-0.0070	-0.0133
C	11	5	0.0736	0.0270
S	11	5	0.0332	0.0252
C	12	5	0.0399	0.0298
S	12	5	-0.0048	-0.0095
C	13	5	0.0418	0.0
S	13	5	0.0548	0.0
C	14	5	0.0426	0.0
S	14	5	-0.0311	0.0
C	15	5	0.0237	0.0
S	15	5	-0.0175	0.0
C	16	5	0.0160	0.0
S	16	5	0.0334	0.0
C	6	6	0.0313	0.0406
S	6	6	-0.2348	-0.2208
C	7	6	-0.3230	-0.3323
S	7	6	0.1664	0.1563
C	8	6	-0.0476	-0.0346
S	8	6	0.2841	0.3067
C	9	6	0.0651	0.0897
S	9	6	0.2210	0.2286
C	10	6	-0.0178	0.0039
S	10	6	-0.1220	-0.1227

Table 2

GSFC Geopotential Solutions (Normalized Coefficients x 10^6) 2

	L	M	GEM 4	GEM 3
C	11	6	-0.0211	-0.0342
S	11	6	0.0443	0.0605
C	12	6	0.0634	0.0610
S	12	6	-0.0252	-0.0103
C	13	6	-0.1284	0.0
S	13	6	0.0378	0.0
C	14	6	0.0534	0.0
S	14	6	-0.0323	0.0
C	15	6	-0.0174	0.0
S	15	6	-0.0481	0.0
C	16	6	-0.0407	0.0
S	16	6	-0.0189	0.0
C	7	7	0.0752	0.0646
S	7	7	0.0130	0.0381
C	8	7	0.0494	0.0519
S	8	7	0.0679	0.0714
C	9	7	-0.0685	-0.0570
S	9	7	-0.0212	-0.0276
C	10	7	0.0110	-0.0191
S	10	7	-0.0337	-0.0371
C	11	7	0.0223	0.0113
S	11	7	-0.1104	-0.1156
C	12	7	-0.0335	-0.0223
S	12	7	0.0005	0.0108
C	13	7	-0.0526	0.0
S	13	7	0.1473	0.0
C	14	7	0.1313	0.0
S	14	7	-0.0797	0.0
C	15	7	-0.0214	0.0
S	15	7	0.0968	0.0
C	16	7	0.0258	0.0
S	16	7	-0.0462	0.0
C	8	8	-0.1075	-0.0926
S	8	8	-0.1158	0.0974
C	9	8	0.2182	0.1812
S	9	8	0.0052	-0.0296
C	10	8	0.0418	0.0479
S	10	8	-0.1256	-0.1364

	L	M	GEM 4	GEM 3
C	11	8	0.0011	-0.0269
S	11	8	0.0639	0.0336
C	12	8	-0.0317	-0.0342
S	12	8	0.0060	-0.0274
C	13	8	0.0412	0.0
S	13	8	0.0192	0.0
C	14	8	0.0007	0.0
S	14	8	-0.0605	0.0
C	15	8	-0.1600	0.0
S	15	8	0.0290	0.0
C	16	8	-0.0301	0.0
S	16	8	-0.0248	0.0
C	9	9	-0.0273	-0.0347
S	9	9	0.0801	0.0760
C	10	9	0.1062	0.1157
S	10	9	-0.0724	-0.0657
C	11	9	-0.0505	-0.0138
S	11	9	0.0857	0.0469
C	12	9	0.0081	0.0343
S	12	9	0.0208	0.0331
C	13	9	0.0137	0.0531
S	13	9	0.1196	0.0707
C	14	9	0.0116	0.0406
S	14	9	0.0460	0.0602
C	15	9	0.0066	0.0380
S	15	9	0.0769	0.0495
C	16	9	0.0409	0.0
S	16	9	-0.0608	0.0
C	10	10	0.0786	0.0641
S	10	10	-0.0232	-0.0094
C	11	10	-0.0727	-0.1086
S	11	10	-0.0063	0.0047
C	12	10	-0.0057	-0.0218
S	12	10	0.0312	0.0569
C	13	10	-0.0128	0.0
S	13	10	0.0171	0.0
C	14	10	0.0273	0.0
S	14	10	-0.1311	0.0

	L	M	GEM 4	GEM 3 [3]
C	15	10	0.0503	0.0
S	15	10	0.0345	0.0
C	16	10	-0.0602	0.0
S	16	10	-0.0093	0.0
C	11	11	0.0900	0.0848
S	11	11	-0.0255	-0.0221
C	12	11	0.0052	0.0093
S	12	11	0.0305	0.0337
C	13	11	-0.0443	0.0
S	13	11	-0.0215	0.0
C	14	11	0.0980	0.0
S	14	11	-0.0331	0.0
C	15	11	-0.0567	0.0
S	15	11	0.0568	0.0
C	16	11	0.0046	0.0
S	16	11	-0.0064	0.0
C	12	12	-0.0117	-0.0120
S	12	12	0.0049	0.0052
C	13	12	-0.0306	-0.0300
S	13	12	0.0994	0.0991
C	14	12	0.0098	0.0090
S	14	12	-0.0268	-0.0241
C	15	12	-0.0341	-0.0327
S	15	12	0.0153	0.0151
C	16	12	0.0256	0.0235
S	16	12	-0.0076	-0.0019
C	17	12	0.0261	0.0283
S	17	12	-0.0011	-0.0003
C	18	12	-0.0568	-0.0572
S	18	12	-0.0229	-0.0182
C	19	12	-0.0256	-0.0244
S	19	12	-0.0203	-0.0201
C	20	12	0.0121	0.0092
S	20	12	-0.0623	0.0066
C	21	12	0.0072	0.0113
S	21	12	-0.0347	-0.0326
C	22	12	-0.0537	-0.0531
S	22	12	-0.0333	-0.0315

	L	M	GEM 4	GEM 3 [3]
C	13	13	-0.0274	-0.0262
S	13	13	0.0930	0.0951
C	14	13	0.0318	0.0302
S	14	13	0.0087	0.0045
C	15	13	-0.0023	-0.0014
S	15	13	0.0107	0.0120
C	16	13	0.0064	0.0044
S	16	13	-0.0213	-0.0219
C	17	13	0.0319	0.0324
S	17	13	0.0423	0.0436
C	18	13	-0.0027	-0.0039
S	18	13	-0.0834	-0.0897
C	19	13	-0.0068	-0.0062
S	19	13	-0.0012	-0.0003
C	20	13	0.0312	0.0277
S	20	13	-0.0637	-0.0725
C	21	13	-0.0190	-0.0188
S	21	13	0.0257	0.0263
C	22	13	-0.0137	-0.0180
S	22	13	-0.0348	-0.0398
C	14	14	-0.0521	-0.0519
S	14	14	-0.0074	-0.0081
C	15	14	0.0025	0.0026
S	15	14	-0.0216	-0.0212
C	16	14	-0.0108	-0.0139
S	16	14	-0.0374	-0.0374
C	17	14	-0.0155	-0.0159
S	17	14	0.0060	0.0051
C	18	14	-0.0234	-0.0218
S	18	14	-0.0043	-0.0044
C	19	14	0.0005	0.0008
S	19	14	-0.0109	-0.0102
C	20	14	0.0117	0.0127
S	20	14	-0.0035	-0.0024
C	21	14	0.0042	0.0045
S	21	14	0.0134	0.0138
C	22	14	0.0215	0.0206
S	22	14	0.0071	0.0079

	L	M	GEM 4	GEM 3
C	15	15	-0.0788	0.0
S	15	15	0.0308	0.0
C	16	15	-0.0544	0.0
S	16	15	0.0090	0.0
C	16	16	-0.0048	0.0
S	16	16	-0.0036	0.0

Table 3A

Satellite Optical Data

300 Weekly Satellite Arcs Opt. Data (Primarily SAO Baker-Nunn)

Satellite Name	A (Meters)	E	I (Deg)	Perigee Height (km)	Period (Rev./Day)	No. Arcs	No. Obs.	Avg. No. Obs./Arc	Avg. RMS (Weighted)
TELSTAR-1	9669530.1	0.2421	44.79	951.3	9.13	16	1946	121	2.70
TIROS-9	8020761.2	0.1167	96.42	706.7	12.09	14	1525*	109	1.16
GEOS-1	8067353.6	0.0725	59.37	1107.5	11.98	35	45555**	1301	1.28
SECOR-5	8154869.9	0.0801	69.23	1140.1	11.79	4	290	72	2.38
OV1-2	8314700.2	0.1835	144.27	414.8	11.45	4	910	227	1.93
ALOU-2	8097474.4	0.1508	79.83	502.0	11.91	6	590*	98	0.89
ECHO-IRB	7968879.1	0.0121	47.22	1501.0	12.20	18	2240	124	2.24
DI-D	7614681.9	0.0842	39.45	589.0	13.07	9	6386	709	1.86
BE-C	7503563.5	0.0252	41.17	941.9	13.36	22	4947	224	1.59
DI-C	7344163.4	0.0526	40.00	586.6	13.79	4	902	225	2.53
ANNA-1B	7504950.8	0.0070	50.13	1075.8	13.35	40	4183	104	1.51
GEOS-2	7710806.6	0.0308	105.79	1114.2	12.82	24	25315**	1054	1.75
OSCAR-7	7404041.3	0.0242	89.70	847.7	13.63	4	1780	445	2.34
SBN-2	7463226.9	0.0058	89.95	1062.5	13.47	5	355	71	5.17
COLRICR-1B	7473289.0	0.0174	28.34	988.5	13.44	12	3375	281	1.66
GRS	7228289.3	0.0604	49.72	421.3	14.13	5	369	73	3.06
TRANSIT-4A	7321521.7	0.0079	66.83	806.0	13.86	14	1316	94	1.92
AE-B	7364785.0	0.0143	79.70	901.8	13.74	4	469	117	1.87
OGO-2	7345633.6	0.0739	87.37	424.8	13.79	7	461	65	3.47
INJUN-1	7312542.4	0.0076	66.81	895.0	13.88	9	768	85	2.15
AGENA-R	7297251.5	0.0010	69.91	920.2	13.93	7	1005	143	2.86
MIDAS-4	9995760.5	0.0121	95.84	1504.8	8.69	20	14879	743	1.20
VANGUARD-2	8306759.8	0.1645	32.89	566.7	11.47	11	379	34	1.13
VANGUARD-2S	8309120.5	0.1648	32.87	562.2	11.46	5	615	123	2.29
VANGUARD-3S	8511504.6	0.1906	33.35	517.9	11.06	15	996	66	2.89
					Summary Totals	314	121556	388	3.4"

*Minitrack
**MOTS
46,000 obs.
GEOS I & II

Table 3B

Satellite Electronic, Laser, and Additional Optical Data (48 Weekly Orbital Arcs)

	DI-C	BE-B	BE-C	DI-D	GEOS-I	GEOS-II	SAS	PEOLE	Total
Baker-Nunn	450 (80)*	60 (20)	160 (50)	500 (80)	2780 (500)	550 (120)			4,500 (850)
MOTS					2700 (350)	3300 (550)			6,000 (900)
GRARR						103000 (300)			103,000 (300)
Laser	680 (7)	100 (5)	160 (7)	1410 (5)		7350 (35)		200 (21)	9,900 (80)
Doppler		12200 (550)	14000 (850)		99500 (2700)	37700 (1400)			163,400 (5500)
C-Band						4000 (100)			4,000 (100)
Mini-Track							700 (85)	500 (65)	1,200 (150)
Total	1130 (87)	12360 (575)	14320 (970)	1910 (85)	104980 (3550)	155900 (2500)	700 (85)	700 (85)	292,000 (7900)
No. of Arcs	2	6	6	1	13	12	4	4	48

*Observations (passes)

Table 4

Comparison of Zonal Coefficients (Normalized Coefficients x 10^6)

DEGREE	FRENCH 1971	GEM 3	GEM 4	SAO 1969	GEM 1	GEM 2
2	-484.170	-484.171	-484.169	-484.166	-484.177	-484.167
3	.961	.958	.957	.959	.962	.955
4	.540	.547	.541	.531	.557	.537
5	.068	.068	.069	.069	.062	.073
6	-.155	-.162	-.153	-.139	-.178	-.145
7	.094	.092	.091	.094	.105	.087
8	.051	.062	.051	.029	.080	.040
9	.027	.030	.031	.023	.008	.033
10	.051	.040	.050	.077	.021	.065
11	-.049	-.056	-.056	-.042	-.020	-.055
12	.038	.046	.039	.008	.059	.021
13	.039	.049	.048	.024	.002	.043
14	-.016	-.030	-.027	.014	-.037	-.009
15	.015	-.007	-.005	.031	.047	.004
16	-.008	-.012	-.009	-.033	-.013	-.026
17	.005	.020	.017	.014	-.035	.007
18	.023	.016	.011	.038	.018	.023
19	.018	.008	.009	.035	.045	.015
20	.014	.003	.009	.001	-.002	-.001
21	-.016	-.008	-.008	-.022	-.031	-.012
22		-.001	-.004			

Differences with French Zonals x 10^9

DEGREE	GEM 3	GEM 4	SAO	GEM 1	GEM 2
2	- 1	1	4	- 7	3
3	- 3	- 4	- 2	1	- 6
4	7	1	- 9	17	- 3
5	0	1	1	- 6	5
6	- 7	2	16	-23	10
7	- 2	- 3	0	11	- 7
8	11	0	-22	29	-11
9	3	4	- 4	-19	6
10	-11	1	26	-30	14
11	- 7	- 7	7	29	- 6
12	8	1	-30	21	-17
13	10	9	-15	-37	4
14	-14	-11	30	-21	7
15	-22	-20	16	32	-11
16	- 4	- 1	-25	- 5	-18
17	15	12	9	-40	2
18	- 7	-12	15	- 5	0
19	-10	- 9	17	27	3
20	-11	- 5	-13	-16	-15
21	8	8	- 6	-15	4
RMS	9.5	7.6	16.3	22.5	9.1

Table 5

GEM 4 Station Coordinate Solution

TYPE	STATION NAME	STATION NUMBER	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	HEIGHT M	MSL M	GEOID HEIGHT M	RES M
M	1BPOIN	1021	38	25	49.920	282	54	48.543	-42.3	5.8	-42.3	-5.8
M	1FTMYR	1022	26	32	53.408	278	8	4.219	-32.3	4.8	-29.8	-7.3
M	1OOMER	1024	-31	23	25.122	136	52	15.442	129.5	132.8	-3.0	-0.3
M	1SATAG	1028	-33	8	58.371	289	19	53.674	707.9	693.4	23.7	-9.2
M	1MOJAV	1030	35	19	47.898	243	5	59.184	889.5	929.1	-28.9	-10.7
M	1JOBUR	1031	-25	53	0.742	27	42	26.375	1537.3	1522.0	22.3	-7.0
M	1NEWFL	1032	47	44	29.861	307	16	46.193	63.2	69.0	12.0	-17.8
M	1GFORK	1034	48	1	21.333	262	59	19.474	215.2	252.6	-30.1	-7.3
M	1WNKFL	1035	51	26	46.074	359	18	8.307	104.4	67.4	45.3	-8.3
M	1ROSMN	1037	35	12	7.395	277	7	41.380	867.3	909.3	-37.9	-4.1
M	1ORORL	1038	-35	37	32.109	148	57	14.881	944.4	931.6	15.0	-3.2
M	1ROSMA	1042	35	12	7.398	277	7	41.169	867.5	909.4	-37.9	-4.0
M	1TANAN	1043	-19	0	31.629	47	17	59.444	1362.6	1378.0	-5.1	-9.3
M	1UNDAK	7034	48	1	21.403	262	59	19.464	216.7	252.6	-30.1	-5.8
M	1EDINB	7036	26	22	46.796	261	40	7.504	21.3	59.6	-18.9	-19.4
M	1COLBA	7037	38	53	36.235	267	47	40.934	227.6	272.7	-32.3	-12.8
M	1BERMD	7039	32	21	49.897	295	20	35.029	-17.1	31.2	-43.4	-4.9
M	1PURIO	7040	18	15	28.918	294	0	23.629	-7.4	49.7	-47.5	-9.6
M	1GSFCP	7043	39	1	15.736	283	10	20.326	3.0	53.5	-41.9	-8.6
M	1DENVR	7045	39	38	48.050	255	23	38.668	1758.2	1790.0	-21.5	-10.3
M	1JUM40	7072	27	1	14.408	279	53	12.876	-33.6	14.2	-34.2	-13.6
M	1SUDBR	7075	46	27	21.244	279	3	10.410	236.0	281.9	-39.0	-6.9
M	1JAMAC	7076	18	4	34.762	283	11	27.073	419.6	445.9	-25.2	-1.1
B	1ORGAN	9001	32	25	24.986	253	26	49.004	1617.3	1651.0	-23.9	-9.8
B	1OLFAN	9002	-25	57	36.038	28	14	52.527	1561.0	1544.0	21.6	-4.6
B	1OOMER	9003	-31	6	2.109	136	47	3.350	153.7	162.5	-2.7	-6.1
B	1SPAIN	9004	36	27	46.734	353	47	36.956	57.3	25.9	50.0	-18.6
B	1TOKYO	9005	35	40	22.975	139	32	16.555	83.9	59.8	38.2	-14.1
B	1NATOL	9006	29	21	34.687	79	27	27.520	1869.4	1927.0	-50.2	-7.4
B	1QUIPA	9007	-16	27	56.824	288	30	24.601	2484.7	2452.0	29.6	3.1
B	1SHRAZ	9008	29	38	13.743	52	31	11.369	1578.7	1596.0	-9.0	-8.3
B	1CURAC	9009	12	5	25.056	291	9	44.547	-24.4	8.7	-29.3	-3.8
B	1JUPTR	9010	27	1	14.020	279	53	13.375	-24.9	15.1	-34.2	-5.8
B	1VILDO	9011	-31	56	34.718	294	53	36.624	626.6	598.4	24.6	3.6
B	1MAUIO	9012	20	42	26.051	203	44	33.984	3040.4	3034.0	4.5	1.9
B	HOPKIN	9021	31	41	3.174	249	7	18.592	2337.2	2382.0	-26.7	-18.1
B	AUSBAK	9023	-31	23	25.874	136	52	43.675	136.6	141.2	-3.0	-1.6
B	DEZEIT	9028	8	44	51.106	38	57	33.366	1900.8	1924.0	-6.7	-16.5
B	COMRIV	9031	-45	53	12.418	292	23	9.422	195.3	186.5	11.2	-2.4
* B	GREECE	9091	38	4	44.736	23	55	58.650	483.2	467.0	32.1	-15.9
* B	EDWAFB	9425	34	57	50.520	242	5	7.955	747.3	784.2	-30.9	-6.0
* B	JOHNST	9427	16	44	38.733	190	29	9.342	17.3	5.0	10.9	1.4
G	MADGAR	1123	-19	1	14.228	47	18	11.362	1386.9	1399.0	-6.1	-6.0
G	ROSRAN	1126	35	11	45.641	277	7	26.252	827.0	873.9	-37.9	-9.0
G	ULASKR	1128	64	58	19.069	212	29	12.706	341.4	346.6	10.5	-15.7
G	CARVON	1152	-24	54	10.766	113	42	59.736	6.1	37.9	-20.6	-11.2
L	GODLAS	7050	39	1	14.539	283	10	18.706	13.4	54.8	-41.9	0.5
L	WALLAS	7052	37	51	36.235	284	29	23.889	-42.9	8.6	-43.1	-8.4
L	CRMLAS	7054	-24	54	15.794	113	42	58.262	-6.6	31.4	-20.6	-17.4
* D	ANCHOR	2014	61	17	0.152	210	10	28.960	64.0	68.0	15.0	-19.0
D	TAFUNA	2017	-14	19	50.005	189	17	3.159	27.5	6.1	25.5	-5.1
* D	WAHIWA	2100	21	31	15.577	202	0	10.406	396.2	388.0	7.6	0.6
* D	LACRES	2103	32	16	44.546	253	14	45.439	1151.6	1203.0	-24.0	-27.4
* D	LASHAM	2106	51	11	9.350	358	58	25.632	218.5	190.3	45.7	-17.5
* D	APLMND	2111	39	9	48.630	283	6	11.907	95.7	145.0	-41.8	-7.5
* D	THOLEG	2018	76	32	20.076	291	13	52.887	50.7	43.0	13.8	-6.1
* D	PRETOR	2115	-25	56	48.233	28	20	52.072	1581.0	1580.0	21.4	-20.4
* D	ASAMOA	2117	-14	19	50.098	189	17	2.960	38.5	6.0	26.5	6.0
D	MESHED	2817	36	14	26.605	59	37	44.419	953.1	994.6	-19.9	-21.6
D	FRTLMY	2822	12	7	54.040	15	2	6.939	299.1	298.4	13.0	-12.3
D	NBRZIL	2837	-5	54	57.855	324	49	55.940	6.2	41.0	-11.2	-23.6

*MEAN SEA LEVEL HEIGHTS, MSL, FOR THESE SITES MAY NOT BE RELIABLE.
M–MOTS, B–BAKER-NUNN, G–GRARR, L–LASER, D–NWL DOPPLER.

Table 6

Comparison of Satellite and Combination Solutions with Surface Gravity Measurements ($mgal^2$)

	$E[(g_T-g_S)^2]$	$E(g_H^2)$	$E(g_S^2)$	$E(g_T^2)$	$E(\epsilon_S^2)$	$E(\epsilon_T^2)$	$E(\delta_g^2)$
$n \geq 5$ 1284 5° x 5° Blocks							
GEM 1	261	198	222	435	24	55	182
GEM 2	197	237	235	435	-1	55	143
GEM 3	252	204	225	435	21	55	176
GEM 4	208	242	257	435	14	55	137
Combination - with SURGRAV (20, 20) Wt. = 5	179	274	291	435	17	55	106
Combination - with SURGRAV (20, 20) Wt. = 10	172	276	290	435	13	55	104
SAO 1969	261	211	248	435	36	55	169
$n \geq 10$ 881 5° x 5° Blocks							
GEM 1	242	211	234	429	23	35	183
GEM 2	176	245	237	429	-8	35	149
GEM 3	231	216	235	429	18	35	177
GEM 4	186	251	259	429	7	35	143
Combination - with SURGRAV (20, 20) Wt. = 5	153	285	294	429	9	35	109
Combination - with SURGRAV (20, 20) Wt. = 10	146	287	292	429	5	35	106
SAO 1969	241	228	267	429	39	35	166

Table 6 (continued)

	$E[(g_T-g_S)^2]$	$E(g_H^2)$	$E(g_S^2)$	$E(g_T^2)$	$E(\varepsilon_S^2)$	$E(\varepsilon_T^2)$	$E(\delta_g^2)$
n ≥ 15 624 5° x 5° Blocks							
GEM 1	249	194	220	417	26	28	195
GEM 2	179	230	221	417	-8	28	159
GEM 3	238	199	220	417	21	28	189
GEM 4	188	235	241	417	6	28	154
Combination - with SURGRAV (20, 20) Wt. = 5	152	265	266	417	1	28	123
Combination - with SURGRAV (20, 20) Wt. = 10	144	268	265	417	-4	28	120
SAO 1969	242	218	261	417	43	28	171
n ≥ 20 434 5° x 5° Blocks							
GEM 1	216	181	211	367	30	23	163
GEM 2	154	210	209	367	-2	23	133
GEM 3	208	185	211	367	26	23	159
GEM 4	164	214	226	367	12	23	130
Combination - with SURGRAV (20, 20) Wt. = 5	130	241	245	367	4	23	103
Combination - with SURGRAV (20, 20) Wt. = 10	124	243	243	367	0	23	101
SAO 1969	200	205	244	367	38	23	138

Table 6 (continued)

n = 25 233 5° x 5° Blocks							
	$E[(g_T-g_S)^2]$	$E(g_H^2)$	$E(g_S^2)$	$E(g_T^2)$	$E(\varepsilon_S^2)$	$E(\varepsilon_T^2)$	$E(\delta_g^2)$
GEM 1	213	182	204	374	22	23	168
GEM 2	153	212	204	374	-8	23	138
GEM 3	204	188	206	374	18	23	163
GEM 4	160	218	221	374	4	23	133
Combination - with SURGRAV (20, 20) Wt. = 5	125	254	258	374	5	23	97
Combination - with SURGRAV (20, 20) Wt. = 10	119	256	258	374	1	23	94
SAO 1969	224	191	232	374	41	23	160

Table 7

σ_n^2 Degree Variances of Gravity Anomalies

Degree n	GEM 3	GEM 4	SAO 69	20 x 20 Field
0	—	3.5	2.1	3.0
2	7.3	7.3	7.3	7.3
3	33.707	33.699	32.842	33.717
4	21.317	21.343	21.805	21.312
5	21.895	21.968	17.785	21.965
6	19.029	19.324	15.652	19.263
7	19.885	19.287	15.491	19.211
8	10.968	10.117	6.639	10.081
9	11.273	11.347	12.651	11.406
10	11.893	10.438	12.860	10.473
11	7.902	8.375	12.234	8.059
12	5.201	5.360	5.099	5.595
13	4.222	17.586	11.121	19.436
14	1.739	14.818	8.431	14.986
15	1.097	17.230	13.215	17.380
16	0.600	6.911	13.844	7.078
17	1.081	0.995	2.253	19.307
18	3.432	3.152	1.667	18.166
19	0.373	0.409	3.545	25.274
20	2.186	1.870	1.693	9.646
21	0.957	0.968	0.185	0.763
22	2.620	2.496	0.0	2.076

Table 8

Weighted RMS of Optical Observation Residuals on 23 Satellites
(weight = 1/2 of a second of arc)

Satellites	SAO S.E. II	GEM 1
TELSTAR	2.46	0.95
GEOS-A	1.08	0.92
SECOR	1.36	1.27
OV1-2	2.10	2.06
ECHO	1.31	1.16
D1-D	2.50	1.66
BE-C	1.16	0.92
D1-C	1.88	1.08
ANNA-1B	1.33	1.16
GEOS-B	1.22	0.90
OSCAR	1.34	1.17
5BN-2	2.61	2.56
COURIER	1.28	1.44
GRS	2.64	1.89
TRANSIT	1.33	1.23
BE-B	1.44	1.29
OGO-2	2.93	1.49
INJUN	2.00	2.28
AGENA	2.45	1.88
MIDAS	0.87	0.86
VANG-2R	0.87	0.80
VANG-2S	1.53	1.42
VANG-3S	1.64	1.26
TOTAL	39.33	31.65
Average rms (in seconds of arc)	3.42"	2.75"

APPENDIX

DESCRIPTION AND TABULATION OF 5° x 5° MEAN GRAVITY ANOMALIES

The source of most of the gravimetry data was the U.S. Aeronautical Chart and Information Center[5] which provided 19,000 one-degree by one-degree mean free-air gravity anomalies. A further set of 2000 mean gravity anomalies were obtained from a number of other sources. These data were used to form 1707 five-degree by five-degree mean gravity anomalies by a straight averaging of the one-degree by one-degree mean anomalies, and provided a total coverage of about 70% of the earth's surface. (See Figure 1 in reference 1 for a map of surface gravity data coverage.)

Table A-1 lists the 1707 5°-by-5° mean anomalies represented at the mid-point of the 5°-by-5° block in latitude and longitude. The mean anomalies listed are referred to the ellipsoid and normal gravity whose parameters are:

$$a_e = 6378155 \text{ meters}$$

$$f = 1/298.255$$

$$GM = 3.986013 \times 10^{14} \text{ m}^3/\text{sec}^2$$

$$\omega = 0.7292115146 \times 10^{-4} \text{ radians/sec}$$

The original gravity anomalies Δg_I, referred to the International Gravity Formula (γ_I), were converted to Δg_R in the above reference system as follows:

$$g_o{}^1 = \Delta g_I + \gamma_I ,$$

$$g_o = g_o{}^1 + \text{Potsdam correction,}$$

and

$$\Delta g_R = g_o - \gamma_R ,$$

or

$$\Delta g_R = \Delta g_I + \gamma_I - \gamma_R + \text{Potsdam correction,}$$

where

$$\gamma_R = \gamma_e \,(1 + \beta \sin^2\phi + \beta^* \sin^2 2\phi).$$

The above quantities are defined as follows:

g_o^1 denotes measured gravity reduced to the geoid (mean sea-level) in the Potsdam system,

Δg_I is the gravity anomaly in the International system,

γ_I is normal gravity on the International Ellipsoid,

g_o is measured gravity reduced to the geoid in the absolute system,

Potsdam correction is the constant correction needed to convert Potsdam system values to an absolute system.

γ_R is normal gravity on the reference ellipsoid, and

Δg_R is the mean anomaly in the reference system.

The equatorial gravity (γ_e) and the constants β and $\beta*$ are obtained from the reference parameter of GM, a_e, f, and ω by the following relations:(6)

$$GM = a^2 (1 - f) \gamma_e \left(1 + \frac{3}{2} m + \frac{3}{7} fm + \frac{9}{4} m^2\right),$$

$$\beta = \beta_1 + \beta_2$$

$$\beta* = - \frac{1}{4} \beta_2$$

$$\beta_1 = -f + \frac{5}{2} m + \frac{1}{2} f^2 - \frac{26}{7} fm + \frac{15}{4} m^2,$$

$$\beta_2 = - \frac{1}{2} f^2 + \frac{5}{2} fm,$$

$$m = \frac{\omega^2 a^3 (1 - f)}{GM}$$

From the above,

$$\gamma_R = 978.0291 (1.0 + 0.0053025 \sin^2\phi - 0.00000585 \sin^2 2\phi) \text{ gal}$$

and

$$\gamma_I = 978.049 \, (1.0 + 0.0052884 \sin^2\phi - 0.0000059 \sin^2 2\phi) \text{ gal.}$$

With an adopted value for the Potsdam correction of -13.7 mgals, the converted anomalies (in mgals) become,

$$\Delta g_R = \Delta g_I + 6.2 - 13.7 \sin^2\phi.$$

In Table A-1 that follows, the columns are labeled PHI, LAMDA, DEL G, and N, where

PHI is the latitude of the midpoint of the 5° x 5° block,

LAMDA is the longitude of the midpiont of the block,

DEL G is the mean anomaly (Δg_R) in the reference system given above, and

N is the number of 1° x 1° mean anomalies within a 5° x 5° block.

Table A-1
5° x 5° Mean Gravity Anomalies

PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N
87.5	352.5	-17.5	1.0	87.5	332.5	-2.5	2.0	87.5	287.5	-0.5	3.0	87.5	282.5	-8.3	8.0
87.5	277.5	15.4	11.0	87.5	272.5	16.9	14.0	87.5	267.5	15.3	9.0	87.5	262.5	23.0	2.0
87.5	247.5	37.9	3.0	87.5	242.5	37.4	6.0	87.5	237.5	13.7	20.0	87.5	232.5	18.6	20.0
87.5	227.5	16.6	20.0	87.5	222.5	13.8	20.0	87.5	217.5	11.1	20.0	87.5	212.5	11.1	20.0
87.5	207.5	12.3	20.0	87.5	202.5	10.7	20.0	87.5	197.5	7.8	20.0	87.5	192.5	10.5	21.0
87.5	187.5	10.8	20.0	87.5	182.5	10.8	20.0	87.5	2.5	11.2	3.0	82.5	357.5	17.7	1.0
82.5	352.5	27.7	4.0	82.5	297.5	-7.3	2.0	82.5	292.5	15.7	7.0	82.5	287.5	67.7	2.0
82.5	282.5	1.1	6.0	82.5	277.5	-24.3	3.0	82.5	272.5	1.1	3.0	82.5	262.5	-8.3	1.0
82.5	257.5	-2.3	2.0	82.5	247.5	20.7	1.0	82.5	242.5	18.2	2.0	82.5	237.5	13.2	10.0
82.5	232.5	13.8	10.0	82.5	227.5	15.9	15.0	82.5	222.5	17.2	17.0	82.5	217.5	11.1	25.0
82.5	212.5	11.4	25.0	82.5	207.5	3.1	25.0	82.5	202.5	1.9	25.0	82.5	197.5	-1.0	25.0
82.5	192.5	-0.6	25.0	82.5	187.5	2.5	25.0	82.5	182.5	7.0	25.0	82.5	177.5	15.7	2.0
82.5	172.5	-2.8	2.0	82.5	57.5	101.7	1.0	82.5	42.5	-1.3	1.0	82.5	22.5	56.7	2.0
82.5	17.5	-26.3	1.0	82.5	12.5	-21.3	1.0	82.5	7.5	15.7	1.0	82.5	2.5	33.2	2.0
77.5	352.5	68.1	1.0	77.5	347.5	30.4	4.0	77.5	337.5	-66.9	1.0	77.5	332.5	0.1	5.0
77.5	327.5	4.9	5.0	77.5	322.5	-25.9	6.0	77.5	317.5	9.5	13.0	77.5	312.5	-4.0	6.0
77.5	307.5	18.6	7.0	77.5	302.5	29.8	10.0	77.5	297.5	44.6	8.0	77.5	292.5	30.1	7.0
77.5	287.5	-21.4	2.0	77.5	282.5	16.1	6.0	77.5	277.5	-6.7	15.0	77.5	272.5	-4.2	3.0
77.5	267.5	9.1	4.0	77.5	262.5	8.1	1.0	77.5	257.5	-6.1	15.0	77.5	252.5	-11.4	2.0
77.5	247.5	16.1	10.0	77.5	242.5	26.6	6.0	77.5	237.5	-8.1	12.0	77.5	232.5	0.7	20.0
77.5	227.5	-14.0	23.0	77.5	222.5	-18.9	25.0	77.5	217.5	-12.0	25.0	77.5	212.5	0.5	25.0
77.5	207.5	-2.2	25.0	77.5	202.5	7.6	25.0	77.5	197.5	12.6	25.0	77.5	192.5	7.5	25.0
77.5	187.5	-1.2	22.0	77.5	182.5	12.9	20.0	77.5	177.5	-2.2	12.0	77.5	172.5	-16.0	6.0
77.5	137.5	-88.4	2.0	77.5	97.5	-2.9	2.0	77.5	72.5	-20.2	3.0	77.5	67.5	-16.4	2.0
77.5	62.5	-13.2	3.0	77.5	57.5	-7.3	5.0	77.5	52.5	-7.4	6.0	77.5	42.5	10.1	1.0
77.5	37.5	-6.4	2.0	77.5	32.5	7.1	1.0	77.5	22.5	-4.2	3.0	77.5	17.5	-16.1	5.0
77.5	12.5	15.6	2.0	72.5	352.5	47.7	2.0	72.5	342.5	-15.3	1.0	72.5	337.5	2.1	3.0
72.5	332.5	21.4	3.0	72.5	327.5	45.8	10.0	72.5	322.5	44.7	9.0	72.5	317.5	23.1	5.0
72.5	312.5	22.2	2.0	72.5	307.5	-14.9	11.0	72.5	302.5	-9.6	6.0	72.5	297.5	14.0	4.0
72.5	292.5	-3.3	1.0	72.5	287.5	-7.5	8.0	72.5	282.5	1.5	10.0	72.5	277.5	-3.3	15.0
72.5	272.5	12.7	1.0	72.5	267.5	9.4	3.0	72.5	262.5	4.7	4.0	72.5	257.5	-19.7	12.0
72.5	252.5	-28.4	6.0	72.5	247.5	-17.6	6.0	72.5	242.5	-24.6	6.0	72.5	237.5	-30.3	2.0
72.5	232.5	3.1	18.0	72.5	227.5	15.5	25.0	72.5	222.5	-15.2	25.0	72.5	217.5	-8.6	24.0
72.5	212.5	-12.0	25.0	72.5	207.5	-18.8	24.0	72.5	202.5	-12.8	25.0	72.5	197.5	4.1	25.0
72.5	192.5	-0.6	24.0	72.5	187.5	1.2	11.0	72.5	182.5	-3.8	7.0	72.5	177.5	-3.3	1.0
72.5	127.5	16.4	25.0	72.5	122.5	8.2	25.0	72.5	117.5	3.8	25.0	72.5	112.5	-8.0	25.0
72.5	107.5	-9.3	25.0	72.5	102.5	-7.3	11.0	72.5	97.5	2.8	10.0	72.5	92.5	-12.0	10.0
72.5	82.5	-2.3	7.0	72.5	67.5	-13.9	5.0	72.5	62.5	-16.1	6.0	72.5	57.5	-1.7	7.0
72.5	52.5	6.4	3.0	72.5	37.5	6.1	3.0	72.5	32.5	4.4	9.0	72.5	27.5	1.1	9.0
72.5	22.5	-0.1	22.0	72.5	17.5	20.4	19.0	72.5	12.5	31.8	16.0	72.5	7.5	21.1	6.0
67.5	347.5	32.2	3.0	67.5	342.5	47.5	10.0	67.5	337.5	34.8	10.0	67.5	327.5	43.5	1.0
67.5	322.5	54.5	2.0	67.5	312.5	11.0	4.0	67.5	307.5	-14.2	19.0	67.5	297.5	15.0	2.0
67.5	292.5	-8.0	21.0	67.5	287.5	-36.4	19.0	67.5	282.5	-39.0	11.0	67.5	277.5	-33.2	9.0
67.5	272.5	-29.0	13.0	67.5	267.5	-34.2	3.0	67.5	262.5	-36.8	12.0	67.5	257.5	-38.2	3.0
67.5	252.5	-28.0	21.0	67.5	247.5	-2.6	19.0	67.5	242.5	0.3	19.0	67.5	237.5	4.3	21.0
67.5	232.5	-1.5	15.0	67.5	227.5	-13.6	7.0	67.5	222.5	3.4	12.0	67.5	217.5	23.0	13.0
67.5	212.5	26.4	22.0	67.5	207.5	17.1	19.0	67.5	202.5	4.1	20.0	67.5	197.5	2.3	21.0
67.5	192.5	-6.4	23.0	67.5	187.5	-0.6	20.0	67.5	182.5	9.2	20.0	67.5	177.5	27.4	13.0
67.5	172.5	16.9	21.0	67.5	167.5	19.8	25.0	67.5	162.5	19.7	25.0	67.5	157.5	13.5	25.0
67.5	152.5	17.6	25.0	67.5	147.5	12.1	25.0	67.5	142.5	14.3	25.0	67.5	137.5	10.9	25.0
67.5	132.5	-1.1	25.0	67.5	127.5	3.7	25.0	67.5	122.5	-20.6	25.0	67.5	117.5	-22.2	25.0
67.5	112.5	-20.6	25.0	67.5	107.5	-15.5	25.0	67.5	102.5	-20.4	25.0	67.5	97.5	-1.5	25.0

Table A-1 (continued)

PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N
67.5	92.5	-16.3	25.0	67.5	87.5	3.8	18.0	67.5	82.5	-15.1	16.0	67.5	77.5	-23.6	9.0
67.5	62.5	-16.5	1.0	67.5	57.5	-6.3	4.0	67.5	52.5	-1.3	4.0	67.5	47.5	-8.1	5.0
67.5	42.5	13.0	4.0	67.5	32.5	11.0	8.0	67.5	27.5	-8.0	6.0	67.5	22.5	-0.9	19.0
67.5	17.5	7.6	25.0	67.5	12.5	14.8	23.0	67.5	7.5	11.1	25.0	67.5	2.5	17.7	21.0
62.5	357.5	12.4	7.0	62.5	352.5	19.3	7.0	62.5	347.5	21.7	5.0	62.5	342.5	45.0	14.0
62.5	337.5	40.9	13.0	62.5	332.5	41.7	6.0	62.5	327.5	34.9	4.0	62.5	322.5	17.1	3.0
62.5	317.5	-63.6	1.0	62.5	312.5	-43.8	6.0	62.5	307.5	-12.1	6.0	62.5	297.5	18.4	23.0
62.5	292.5	-9.6	1.0	62.5	287.5	-10.8	24.0	62.5	282.5	-15.0	24.0	62.5	277.5	-27.4	25.0
62.5	272.5	-33.7	25.0	62.5	267.5	-41.2	25.0	62.5	262.5	-41.3	25.0	62.5	257.5	-32.3	23.0
62.5	252.5	-18.9	25.0	62.5	247.5	-19.8	25.0	62.5	242.5	-11.2	25.0	62.5	237.5	-4.6	25.0
62.5	232.5	6.4	1.0	62.5	227.5	15.4	2.0	62.5	222.5	40.5	3.0	62.5	217.5	41.3	19.0
62.5	212.5	37.8	25.0	62.5	207.5	1.3	12.0	62.5	202.5	18.0	18.0	62.5	197.5	16.0	14.0
62.5	192.5	2.9	18.0	62.5	187.5	0.1	12.0	62.5	162.5	23.3	17.0	62.5	157.5	26.8	17.0
62.5	152.5	20.6	25.0	62.5	147.5	29.3	25.0	62.5	142.5	20.8	25.0	62.5	137.5	4.4	25.0
62.5	132.5	-10.6	25.0	62.5	127.5	-20.6	25.0	62.5	122.5	-19.7	25.0	62.5	117.5	-27.0	25.0
62.5	112.5	-18.1	25.0	62.5	107.5	-24.8	25.0	62.5	102.5	-36.3	25.0	62.5	97.5	-39.1	25.0
62.5	92.5	-27.8	25.0	52.5	87.5	-13.7	25.0	62.5	82.5	-15.6	25.0	52.5	77.5	-18.3	4.0
62.5	72.5	-35.6	1.0	62.5	67.5	-18.6	1.0	62.5	57.5	-1.1	4.0	62.5	52.5	0.2	16.0
62.5	47.5	11.5	19.0	62.5	42.5	3.8	14.0	62.5	37.5	10.0	10.0	62.5	32.5	5.2	18.0
62.5	27.5	-3.3	17.0	62.5	22.5	-15.8	12.0	62.5	17.5	-1.6	23.0	62.5	12.5	9.5	25.0
62.5	7.5	19.3	25.0	62.5	2.5	6.0	24.0	57.5	357.5	11.0	23.0	57.5	352.5	28.7	17.0
57.5	347.5	2.8	8.0	57.5	342.5	14.6	6.0	57.5	322.5	13.8	3.0	57.5	317.5	20.0	5.0
57.5	312.5	-6.2	3.0	57.5	307.5	-1.2	3.0	57.5	302.5	-20.2	5.0	57.5	297.5	18.0	10.0
57.5	292.5	-4.7	8.0	57.5	287.5	-24.4	25.0	57.5	282.5	-53.1	6.0	57.5	277.5	-43.2	3.0
57.5	272.5	-38.2	3.0	57.5	267.5	-35.3	25.0	57.5	262.5	-21.3	25.0	57.5	257.5	-10.1	26.0
57.5	252.5	-12.9	24.0	57.5	247.5	2.9	2.0	57.5	242.5	-5.0	5.0	57.5	237.5	5.0	8.0
57.5	232.5	18.8	3.0	57.5	227.5	9.6	12.0	57.5	222.5	8.3	14.0	57.5	217.5	8.5	8.0
57.5	212.5	25.5	15.0	57.5	207.5	8.5	24.0	57.5	202.5	31.8	20.0	57.5	197.5	44.9	5.0
57.5	192.5	16.5	11.0	57.5	187.5	18.2	13.0	57.5	182.5	-4.2	3.0	57.5	162.5	18.2	5.0
57.5	157.5	39.2	9.0	57.5	137.5	7.5	25.0	57.5	132.5	-11.5	25.0	57.5	127.5	-20.1	25.0
57.5	122.5	-33.7	25.0	57.5	117.5	-33.4	25.0	57.5	112.5	-29.4	25.0	57.5	107.5	-11.1	25.0
57.5	102.5	-16.9	25.0	57.5	97.5	-26.6	25.0	57.5	92.5	-30.5	25.0	57.5	87.5	-8.1	25.0
57.5	82.5	-9.9	25.0	57.5	77.5	-14.5	25.0	57.5	72.5	-17.0	25.0	57.5	67.5	-9.1	25.0
57.5	62.5	4.9	25.0	57.5	57.5	17.8	24.0	57.5	52.5	7.9	19.0	57.5	47.5	11.9	15.0
57.5	42.5	5.8	15.0	57.5	37.5	9.1	17.0	57.5	32.5	2.5	20.0	57.5	27.5	0.6	21.0
57.5	22.5	-10.5	14.0	57.5	17.5	-6.9	19.0	57.5	12.5	4.8	23.0	57.5	7.5	11.1	25.0
57.5	2.5	1.9	24.0	52.5	357.5	12.4	21.0	52.5	352.5	20.1	21.0	52.5	347.5	21.8	10.0
52.5	337.5	19.5	1.0	52.5	332.5	14.3	4.0	52.5	327.5	48.5	2.0	52.5	307.5	4.6	19.0
52.5	302.5	9.1	5.0	52.5	297.5	-22.5	25.0	52.5	292.5	-11.5	1.0	52.5	287.5	-15.9	25.0
52.5	282.5	-30.7	25.0	52.5	277.5	-23.7	23.0	52.5	272.5	-21.5	1.0	52.5	267.5	-6.2	25.0
52.5	262.5	-6.3	25.0	52.5	257.5	5.9	25.0	52.5	252.5	6.0	25.0	52.5	247.5	1.4	6.0
52.5	242.5	-0.1	6.0	52.5	232.5	11.7	9.0	52.5	227.5	-10.7	15.0	52.5	222.5	-1.3	10.0
52.5	217.5	11.0	7.0	52.5	212.5	26.3	5.0	52.5	207.5	-12.5	1.0	52.5	202.5	-18.5	6.0
52.5	197.5	1.1	9.0	52.5	192.5	4.2	19.0	52.5	187.5	-18.3	18.0	52.5	182.5	-40.7	14.0
52.5	177.5	89.5	1.0	52.5	172.5	124.0	2.0	52.5	162.5	32.0	2.0	52.5	157.5	33.0	13.0
52.5	127.5	11.2	9.0	52.5	117.5	7.5	5.0	52.5	112.5	-9.6	9.0	52.5	107.5	-20.5	1.0
52.5	102.5	-29.9	25.0	52.5	97.5	-30.7	25.0	52.5	92.5	-13.8	25.0	52.5	87.5	-4.9	25.0
52.5	82.5	-13.6	25.0	52.5	77.5	-17.8	23.0	52.5	72.5	0.9	16.0	52.5	67.5	3.3	12.0
52.5	62.5	-1.1	25.0	52.5	57.5	4.7	25.0	52.5	52.5	3.3	23.0	52.5	47.5	-2.1	22.0
52.5	42.5	7.8	22.0	52.5	37.5	2.3	20.0	52.5	32.5	7.9	20.0	52.5	27.5	5.4	24.0
52.5	22.5	5.1	19.0	52.5	17.5	3.7	25.0	52.5	12.5	12.9	25.0	52.5	7.5	8.2	25.0
52.5	2.5	-5.6	25.0	47.5	357.5	7.4	25.0	47.5	352.5	-1.2	24.0	47.5	347.5	5.9	18.0

Table A-1 (continued)

PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N
47.5	342.5	17.6	16.0	47.5	337.5	34.4	18.0	47.5	332.5	42.4	15.0	47.5	327.5	27.6	24.0
47.5	322.5	13.4	23.0	47.5	317.5	10.4	15.0	47.5	312.5	17.9	20.0	47.5	307.5	35.9	15.0
47.5	302.5	18.4	10.0	47.5	297.5	-10.0	25.0	47.5	292.5	-4.1	25.0	47.5	287.5	-14.6	25.0
47.5	282.5	-14.4	25.0	47.5	277.5	-5.6	25.0	47.5	272.5	-6.1	19.0	47.5	267.5	-1.5	5.0
47.5	262.5	17.3	5.0	47.5	257.5	20.3	5.0	47.5	252.5	18.7	5.0	47.5	247.5	17.9	23.0
47.5	242.5	-1.4	23.0	47.5	237.5	-6.4	20.0	47.5	232.5	-7.9	19.0	47.5	227.5	-5.7	20.0
47.5	222.5	11.7	2.0	47.5	217.5	-10.3	1.0	47.5	212.5	-6.8	4.0	47.5	207.5	12.7	3.0
47.5	202.5	10.6	8.0	47.5	197.5	23.4	3.0	47.5	192.5	31.5	6.0	47.5	187.5	27.7	6.0
47.5	182.5	34.1	5.0	47.5	172.5	60.7	1.0	47.5	142.5	31.2	2.0	47.5	137.5	31.7	1.0
47.5	132.5	18.5	6.0	47.5	127.5	13.5	12.0	47.5	122.5	17.2	10.0	47.5	117.5	6.0	9.0
47.5	112.5	1.2	2.0	47.5	102.5	-7.8	25.0	47.5	97.5	-17.7	25.0	47.5	92.5	-11.9	25.0
47.5	87.5	-22.6	25.0	47.5	82.5	-29.0	25.0	47.5	77.5	-23.6	25.0	47.5	72.5	-14.0	25.0
47.5	67.5	-11.2	25.0	47.5	52.5	-7.6	10.0	47.5	57.5	-15.8	11.0	47.5	52.5	-24.7	13.0
47.5	47.5	-12.1	17.0	47.5	42.5	2.5	20.0	47.5	37.5	2.8	24.0	47.5	32.5	13.7	24.0
47.5	27.5	19.4	18.0	47.5	22.5	22.6	20.0	47.5	17.5	24.2	24.0	47.5	12.5	18.8	25.0
47.5	7.5	16.2	25.0	47.5	2.5	5.3	25.0	42.5	357.5	10.3	25.0	42.5	352.5	22.5	22.0
42.5	347.5	-3.8	17.0	42.5	342.5	13.9	25.0	42.5	337.5	27.9	25.0	42.5	332.5	38.4	25.0
42.5	327.5	26.9	25.0	42.5	322.5	17.4	25.0	42.5	317.5	6.9	25.0	42.5	312.5	23.4	15.0
42.5	307.5	3.0	18.0	42.5	302.5	-17.0	23.0	42.5	297.5	-10.7	15.0	42.5	292.5	6.6	21.0
42.5	287.5	7.4	25.0	42.5	282.5	-9.9	24.0	42.5	277.5	-7.7	24.0	42.5	272.5	-8.9	25.0
42.5	267.5	-4.7	25.0	42.5	252.5	2.9	25.0	42.5	257.5	9.4	25.0	42.5	252.5	28.6	24.0
42.5	247.5	23.7	25.0	42.5	242.5	13.3	25.0	42.5	237.5	9.3	25.0	42.5	232.5	-6.4	25.0
42.5	227.5	-4.4	18.0	42.5	222.5	-8.8	13.0	42.5	217.5	-6.1	1.0	42.5	212.5	1.6	3.0
42.5	207.5	4.2	4.0	42.5	202.5	4.2	12.0	42.5	197.5	-5.1	3.0	42.5	192.5	-18.1	1.0
42.5	187.5	-10.6	2.0	42.5	177.5	0.3	5.0	42.5	172.5	18.0	7.0	42.5	167.5	-0.8	4.0
42.5	157.5	2.1	9.0	42.5	152.5	7.2	6.0	42.5	147.5	10.9	5.0	42.5	142.5	50.1	18.0
42.5	132.5	37.4	2.0	42.5	127.5	33.0	12.0	42.5	122.5	14.2	12.0	42.5	117.5	12.1	4.0
42.5	112.5	-5.6	2.0	42.5	102.5	6.1	25.0	42.5	97.5	0.4	25.0	42.5	92.5	-21.1	25.0
42.5	87.5	-26.5	25.0	42.5	82.5	-16.2	25.0	42.5	77.5	-2.7	25.0	42.5	72.5	-23.1	25.0
42.5	67.5	-28.9	25.0	42.5	52.5	-10.0	25.0	42.5	57.5	-2.3	25.0	42.5	52.5	-10.1	2.0
42.5	47.5	-7.8	11.0	42.5	42.5	29.7	16.0	42.5	37.5	-27.7	13.0	42.5	32.5	-18.3	17.0
42.5	27.5	4.7	12.0	42.5	22.5	34.5	9.0	42.5	17.5	34.4	17.0	42.5	12.5	13.8	24.0
42.5	7.5	18.8	20.0	42.5	2.5	15.7	22.0	37.5	357.5	19.4	22.0	37.5	352.5	22.9	21.0
37.5	347.5	22.4	12.0	37.5	342.5	5.0	14.0	37.5	337.5	24.5	23.0	37.5	332.5	44.6	25.0
37.5	327.5	47.0	25.0	37.5	322.3	22.9	25.0	37.5	317.5	20.0	25.0	37.5	312.5	-0.8	17.0
37.5	307.5	-5.6	20.0	37.5	302.5	-10.5	12.0	37.5	297.5	-14.3	15.0	37.5	292.5	-19.7	23.0
37.5	287.5	-17.8	24.0	37.5	282.5	5.8	25.0	37.5	277.5	-1.4	25.0	37.5	272.5	0.1	25.0
37.5	267.5	-5.4	24.0	37.5	252.5	-5.7	24.0	37.5	257.5	-1.3	24.0	37.5	252.5	24.5	25.0
37.5	247.5	7.7	24.0	37.5	242.5	4.6	25.0	37.5	237.5	-11.4	25.0	37.5	232.5	-22.0	25.0
37.5	227.5	-19.0	22.0	37.5	222.5	-16.3	14.0	37.5	217.5	-14.1	21.0	37.5	212.5	4.9	9.0
37.5	207.5	1.4	10.0	37.5	202.5	-1.8	11.0	37.5	197.5	-5.9	8.0	37.5	192.5	-12.2	4.0
37.5	182.5	1.1	1.0	37.5	177.5	-6.1	6.0	37.5	172.5	4.5	5.0	37.5	167.5	-11.9	4.0
37.5	162.5	-22.2	4.0	37.5	147.5	45.1	1.0	37.5	142.5	63.2	11.0	37.5	137.5	53.3	16.0
37.5	132.5	35.8	3.0	37.5	127.5	27.0	18.0	37.5	122.5	17.2	8.0	37.5	117.5	-12.3	9.0
37.5	112.5	-21.0	8.0	37.5	102.5	11.5	25.0	37.5	97.5	19.6	25.0	37.5	92.5	10.9	25.0
37.5	87.5	2.7	25.0	37.5	82.5	2.9	25.0	37.5	77.5	-10.2	25.0	37.5	72.5	17.0	25.0
37.5	67.5	-27.4	22.0	37.5	62.5	-29.2	25.0	37.5	57.5	5.0	25.0	37.5	52.5	8.5	11.0
37.5	47.5	58.9	13.0	37.5	42.5	14.1	8.0	37.5	37.5	25.7	8.0	37.5	32.5	-13.9	2.0
37.5	27.5	55.8	7.0	37.5	22.5	9.3	11.0	37.5	17.5	4.2	18.0	37.5	12.5	23.2	23.0
37.5	7.5	35.4	15.0	37.5	2.5	19.9	21.0	32.5	357.5	40.5	25.0	32.5	352.5	54.9	22.0
32.5	347.5	9.0	12.0	32.5	342.5	23.7	10.0	32.5	337.5	-4.2	8.0	32.5	332.5	15.0	5.0
32.5	327.5	24.7	12.0	32.5	322.5	31.8	24.0	32.5	317.5	24.2	23.0	32.5	312.5	4.4	13.0

Table A-1 (continued)

PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N
32.5	307.5	-9.0	18.0	32.5	302.5	-12.2	16.0	32.5	297.5	-6.2	5.0	32.5	292.5	-21.0	16.0
32.5	287.5	-42.8	17.0	32.5	282.5	-9.2	15.0	32.5	277.5	7.6	25.0	32.5	272.5	-1.4	25.0
32.5	267.5	1.5	21.0	32.5	252.5	0.4	24.0	32.5	257.5	-0.5	24.0	32.5	252.5	7.9	25.0
32.5	247.5	-8.0	24.0	32.5	242.5	-9.4	25.0	32.5	237.5	-19.3	19.0	32.5	232.5	-18.2	16.0
32.5	227.5	-14.7	23.0	32.5	222.5	-4.8	18.0	32.5	217.5	-5.1	9.0	32.5	212.5	-14.7	10.0
32.5	207.5	3.6	10.0	32.5	202.5	-4.1	3.0	32.5	197.5	-1.7	9.0	32.5	192.5	-35.8	2.0
32.5	187.5	-27.8	5.0	32.5	182.5	-38.3	2.0	32.5	177.5	-0.8	2.0	32.5	172.5	-20.5	6.0
32.5	167.5	-12.8	8.0	32.5	162.5	-20.2	5.0	32.5	157.5	-5.2	10.0	32.5	152.5	-2.0	8.0
32.5	147.5	0.5	7.0	32.5	142.5	22.9	9.0	32.5	137.5	54.5	13.0	32.5	132.5	26.1	14.0
32.5	127.5	28.8	11.0	32.5	122.5	7.0	4.0	32.5	117.5	-1.1	13.0	32.5	112.5	-30.1	14.0
32.5	107.5	-30.8	3.0	32.5	102.5	-3.9	25.0	32.5	97.5	13.8	25.0	32.5	92.5	13.4	25.0
32.5	87.5	27.9	25.0	32.5	82.5	29.2	25.0	32.5	77.5	34.9	23.0	32.5	72.5	-55.3	24.0
32.5	67.5	51.0	10.0	32.5	62.5	33.1	10.0	32.5	57.5	24.4	25.0	32.5	52.5	32.3	25.0
32.5	47.5	2.3	16.0	32.5	42.5	14.9	3.0	32.5	37.5	36.0	13.0	32.5	32.5	-5.4	14.0
32.5	27.5	-32.9	14.0	32.5	22.5	9.9	16.0	32.5	17.5	6.0	14.0	32.5	12.5	9.8	20.0
32.5	7.5	-22.0	16.0	32.5	2.5	17.2	25.0	27.5	357.5	4.8	11.0	27.5	352.5	10.9	19.0
27.5	347.5	16.9	13.0	27.5	342.5	28.9	9.0	27.5	337.5	-5.6	20.0	27.5	332.5	-2.5	20.0
27.5	327.5	6.1	22.0	27.5	322.5	2.1	19.0	27.5	317.5	14.8	13.0	27.5	312.5	3.9	18.0
27.5	307.5	-13.3	21.0	27.5	302.5	-24.0	22.0	27.5	297.5	-10.8	3.0	27.5	292.5	-23.1	6.0
27.5	287.5	-18.5	11.0	27.5	282.5	-15.7	17.0	27.5	277.5	13.1	24.0	27.5	272.5	3.0	13.0
27.5	267.5	-4.4	20.0	27.5	262.5	-7.4	25.0	27.5	257.5	16.0	25.0	27.5	252.5	13.5	25.0
27.5	247.5	-15.9	20.0	27.5	242.5	-15.6	16.0	27.5	237.5	-26.0	11.0	27.5	232.5	-19.9	7.0
27.5	227.5	-14.4	6.0	27.5	222.5	-13.4	8.0	27.5	217.5	2.5	15.0	27.5	212.5	1.0	16.0
27.5	207.5	-1.5	12.0	27.5	202.5	15.2	1.0	27.5	197.5	11.9	3.0	27.5	192.5	17.2	6.0
27.5	187.5	9.2	5.0	27.5	182.5	-31.8	4.0	27.5	177.5	-7.3	6.0	27.5	172.5	-17.0	5.0
27.5	167.5	-18.8	3.0	27.5	162.5	-11.3	2.0	27.5	157.5	-7.3	2.0	27.5	152.5	6.4	5.0
27.5	147.5	17.2	3.0	27.5	142.5	13.2	6.0	27.5	137.5	24.0	7.0	27.5	132.5	-27.8	2.0
27.5	127.5	32.6	10.0	27.5	122.5	5.2	6.0	27.5	117.5	3.5	12.0	27.5	112.5	-15.9	12.0
27.5	107.5	-32.3	10.0	27.5	102.5	-11.8	25.0	27.5	97.5	-14.9	25.0	27.5	92.5	-22.9	25.0
27.5	87.5	-5.0	25.0	27.5	82.5	-63.5	24.0	27.5	77.5	-30.3	24.0	27.5	72.5	-1.0	25.0
27.5	67.5	1.0	24.0	27.5	52.5	27.0	24.0	27.5	57.5	-3.1	25.0	27.5	52.5	-12.0	25.0
27.5	47.5	0.9	22.0	27.5	42.5	14.0	11.0	27.5	37.5	5.2	7.0	27.5	32.5	11.1	12.0
27.5	27.5	8.2	7.0	27.5	22.5	21.0	5.0	27.5	17.5	14.5	7.0	27.5	12.5	8.1	8.0
27.5	7.5	10.2	25.0	27.5	2.5	-9.1	25.0	22.5	357.5	1.2	15.0	22.5	352.5	-9.5	15.0
22.5	347.5	0.3	20.0	22.5	342.5	7.8	13.0	22.5	337.5	4.5	17.0	22.5	332.5	2.4	15.0
22.5	327.5	9.2	15.0	22.5	322.5	1.6	11.0	22.5	317.5	8.4	10.0	22.5	312.5	-4.8	14.0
22.5	307.5	-24.0	18.0	22.5	302.5	-15.1	23.0	22.5	297.5	-10.6	4.0	22.5	292.5	-18.6	8.0
22.5	287.5	-21.2	9.0	22.5	282.5	21.1	20.0	22.5	277.5	5.0	24.0	22.5	272.5	26.0	21.0
22.5	267.5	9.8	25.0	22.5	262.5	8.5	24.0	22.5	257.5	28.5	22.0	22.5	252.5	-5.5	20.0
22.5	247.5	7.7	7.0	22.5	242.5	-16.0	5.0	22.5	237.5	-16.8	1.0	22.5	232.5	-7.4	7.0
22.5	227.5	-9.9	13.0	22.5	222.5	-4.5	9.0	22.5	217.5	-1.6	11.0	22.5	212.5	-4.2	10.0
22.5	207.5	5.6	17.0	22.5	202.5	43.7	19.0	22.5	197.5	16.8	12.0	22.5	192.5	25.6	10.0
22.5	187.5	11.4	11.0	22.5	182.5	-2.3	13.0	22.5	177.5	-11.5	8.0	22.5	172.5	-0.2	3.0
22.5	167.5	-13.8	2.0	22.5	152.5	-15.2	5.0	22.5	157.5	-12.7	6.0	22.5	152.5	20.8	5.0
22.5	142.5	7.4	4.0	22.5	137.5	4.7	6.0	22.5	132.5	6.6	5.0	22.5	127.5	1.6	10.0
22.5	122.5	5.3	12.0	22.5	117.5	3.4	8.0	22.5	112.5	-7.0	11.0	22.5	107.5	-13.6	11.0
22.5	102.5	-18.0	25.0	22.5	97.5	-10.8	25.0	22.5	92.5	-30.4	21.0	22.5	87.5	-0.3	23.0
22.5	82.5	1.7	25.0	22.5	77.5	5.7	25.0	22.5	72.5	7.2	24.0	22.5	67.5	1.7	12.0
22.5	57.5	-43.8	1.0	22.5	52.5	-27.9	17.0	22.5	47.5	-19.0	14.0	22.5	42.5	23.8	5.0
22.5	37.5	15.0	14.0	22.5	32.5	16.5	3.0	22.5	22.5	-21.8	1.0	22.5	17.5	22.4	9.0
22.5	12.5	6.6	25.0	22.5	7.5	34.2	25.0	22.5	2.5	24.0	23.0	17.5	357.5	12.1	21.0
17.5	352.5	6.9	11.0	17.5	347.5	16.6	21.0	17.5	342.5	16.3	15.0	17.5	337.5	32.5	5.0

Table A-1 (continued)

PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N
17.5	332.5	11.9	2.0	17.5	322.5	-24.1	5.0	17.5	317.5	-17.1	3.0	17.5	312.5	-13.7	9.0
17.5	307.5	-12.1	2.0	17.5	302.5	-37.8	7.0	17.5	297.5	-31.5	15.0	17.5	292.5	-7.3	17.0
17.5	287.5	45.8	17.0	17.5	282.5	6.5	15.0	17.5	277.5	10.8	13.0	17.5	272.5	36.1	17.0
17.5	267.5	20.0	21.0	17.5	252.5	32.9	14.0	17.5	257.5	-19.4	16.0	17.5	252.5	-8.6	22.0
17.5	247.5	-15.1	6.0	17.5	242.5	-15.7	8.0	17.5	237.5	-27.4	3.0	17.5	232.5	-20.6	4.0
17.5	227.5	-20.1	2.0	17.5	222.5	-10.6	8.0	17.5	217.5	-13.7	3.0	17.5	212.5	13.6	6.0
17.5	207.5	-1.6	8.0	17.5	202.5	64.8	8.0	17.5	197.5	6.1	10.0	17.5	192.5	-7.1	3.0
17.5	187.5	-19.3	5.0	17.5	182.5	-0.1	7.0	17.5	177.5	2.6	13.0	17.5	172.5	-12.1	12.0
17.5	167.5	1.3	6.0	17.5	32.5	10.2	4.0	17.5	22.5	3.1	14.0	17.5	17.5	-7.0	14.0
17.5	12.5	1.5	24.0	17.5	7.5	10.2	25.0	17.5	2.5	12.5	25.0	12.5	357.5	7.4	25.0
12.5	352.5	14.6	23.0	12.5	347.5	15.3	15.0	12.5	342.5	25.1	14.0	12.5	337.5	-9.1	10.0
12.5	332.5	-1.7	9.0	12.5	327.5	-15.4	4.0	12.5	322.5	24.0	2.0	12.5	317.5	-12.7	16.0
12.5	312.5	-24.8	9.0	12.5	307.5	-24.5	15.0	12.5	302.5	-42.9	22.0	12.5	297.5	-19.0	15.0
12.5	292.5	-39.8	16.0	12.5	287.5	-20.4	18.0	12.5	282.5	-8.3	15.0	12.5	277.5	31.5	10.0
12.5	272.5	28.2	19.0	12.5	267.5	11.7	13.0	12.5	262.5	7.2	9.0	12.5	257.5	5.3	5.0
12.5	252.5	-6.4	2.0	12.5	242.5	-14.6	5.0	12.5	217.5	5.1	5.0	12.5	212.5	4.9	5.0
12.5	202.5	23.3	4.0	12.5	197.5	6.4	11.0	12.5	192.5	4.7	6.0	12.5	187.5	-13.7	4.0
12.5	182.5	49.0	2.0	12.5	177.5	40.8	5.0	12.5	167.5	-9.4	3.0	12.5	162.5	-8.7	4.0
12.5	157.5	-1.8	6.0	12.5	152.5	0.5	10.0	12.5	147.5	-15.3	9.0	12.5	142.5	36.4	10.0
12.5	137.5	22.0	2.0	12.5	132.5	9.5	1.0	12.5	127.5	41.1	9.0	12.5	122.5	57.5	17.0
12.5	117.5	18.5	15.0	12.5	112.5	7.2	6.0	12.5	107.5	5.2	24.0	12.5	102.5	-6.6	19.0
12.5	97.5	0.6	22.0	12.5	92.5	-15.3	11.0	12.5	82.5	-37.9	2.0	12.5	77.5	-19.1	24.0
12.5	72.5	-37.1	13.0	12.5	57.5	-34.1	9.0	12.5	62.5	-14.3	3.0	12.5	57.5	2.5	20.0
12.5	52.5	1.9	20.0	12.5	47.5	5.3	15.0	12.5	42.5	9.4	18.0	12.5	37.5	29.6	13.0
12.5	32.5	0.5	1.0	12.5	27.5	10.5	5.0	12.5	22.5	-4.4	2.0	12.5	17.5	8.0	4.0
12.5	12.5	11.7	18.0	12.5	7.5	12.3	15.0	12.5	2.5	5.0	22.0	7.5	357.5	20.2	25.0
7.5	352.5	32.2	25.0	7.5	347.5	38.3	13.0	7.5	342.5	17.0	7.0	7.5	332.5	4.0	11.0
7.5	327.5	13.5	11.0	7.5	322.5	-9.3	10.0	7.5	317.5	-17.4	13.0	7.5	312.5	-32.6	15.0
7.5	307.5	-26.2	10.0	7.5	302.5	-25.2	5.0	7.5	297.5	-19.4	5.0	7.5	292.5	-1.9	6.0
7.5	287.5	22.4	20.0	7.5	282.5	45.0	19.0	7.5	277.5	25.0	23.0	7.5	272.5	24.4	15.0
7.5	267.5	9.8	7.0	7.5	252.5	10.9	5.0	7.5	257.5	5.8	5.0	7.5	252.5	0.8	5.0
7.5	247.5	-6.8	5.0	7.5	242.5	-6.7	6.0	7.5	202.5	38.2	5.0	7.5	197.5	36.0	2.0
7.5	192.5	2.2	9.0	7.5	187.5	-7.0	8.0	7.5	182.5	6.5	4.0	7.5	177.5	23.6	3.0
7.5	172.5	225.0	1.0	7.5	157.5	12.4	5.0	7.5	152.5	8.1	3.0	7.5	147.5	12.1	13.0
7.5	142.5	16.8	6.0	7.5	137.5	25.4	7.0	7.5	132.5	28.1	11.0	7.5	127.5	23.9	10.0
7.5	122.5	65.7	9.0	7.5	117.5	22.2	11.0	7.5	112.5	11.1	11.0	7.5	107.5	9.8	11.0
7.5	102.5	15.7	7.0	7.5	97.5	11.8	25.0	7.5	92.5	-18.2	21.0	7.5	87.5	-23.3	13.0
7.5	82.5	-26.6	19.0	7.5	77.5	-31.0	18.0	7.5	72.5	-40.3	21.0	7.5	67.5	-34.7	17.0
7.5	62.5	-18.6	12.0	7.5	57.5	1.2	18.0	7.5	52.5	-48.8	15.0	7.5	42.5	19.4	5.0
7.5	37.5	36.3	14.0	7.5	22.5	-11.0	3.0	7.5	17.5	14.0	2.0	7.5	12.5	23.7	11.0
7.5	7.5	31.4	12.0	7.5	2.5	22.5	15.0	2.5	357.5	19.2	1.0	2.5	352.5	18.2	4.0
2.5	347.5	-3.2	6.0	2.5	342.5	-10.1	4.0	2.5	332.5	9.4	12.0	2.5	327.5	14.8	18.0
2.5	322.5	-1.1	13.0	2.5	317.5	-15.5	6.0	2.5	312.5	-11.8	1.0	2.5	307.5	-4.3	4.0
2.5	302.5	-36.6	2.0	2.5	292.5	22.2	1.0	2.5	287.5	29.8	25.0	2.5	282.5	26.7	25.0
2.5	277.5	10.8	10.0	2.5	272.5	5.7	2.0	2.5	267.5	14.2	1.0	2.5	197.5	35.2	5.0
2.5	192.5	17.2	2.0	2.5	187.5	-0.3	11.0	2.5	182.5	10.8	12.0	2.5	177.5	13.4	5.0
2.5	157.5	10.6	5.0	2.5	152.5	6.2	8.0	2.5	147.5	17.0	13.0	2.5	142.5	17.6	11.0
2.5	137.5	2.2	2.0	2.5	132.5	60.8	3.0	2.5	127.5	17.7	11.0	2.5	122.5	35.8	11.0
2.5	117.5	14.2	1.0	2.5	112.5	28.5	6.0	2.5	107.5	24.4	14.0	2.5	102.5	24.8	9.0
2.5	97.5	-9.5	18.0	2.5	92.5	-8.9	19.0	2.5	87.5	-20.2	9.0	2.5	82.5	-51.6	12.0
2.5	77.5	-53.9	10.0	2.5	72.5	-43.5	17.0	2.5	67.5	-31.0	9.0	2.5	62.5	-16.3	20.0
2.5	57.5	-14.1	20.0	2.5	52.5	-25.9	17.0	2.5	47.5	-32.3	14.0	2.5	42.5	-33.3	2.0

Table A-1 (continued)

PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N
2.5	37.5	3.2	4.0	2.5	32.5	7.2	20.0	2.5	27.5	0.3	10.0	2.5	22.5	-32.3	13.0
2.5	17.5	-13.0	8.0	2.5	12.5	28.7	4.0	2.5	7.5	22.8	3.0	-2.5	352.5	10.8	3.0
-2.5	347.5	13.2	8.0	-2.5	342.5	-11.8	7.0	-2.5	337.5	-7.2	14.0	-2.5	332.5	2.6	19.0
-2.5	327.5	-3.1	11.0	-2.5	322.5	11.2	7.0	-2.5	317.5	-25.2	15.0	-2.5	312.5	-26.5	22.0
-2.5	307.5	6.2	4.0	-2.5	302.5	-21.8	2.0	-2.5	297.5	-11.8	1.0	-2.5	292.5	48.8	3.0
-2.5	287.5	50.6	5.0	-2.5	282.5	15.3	11.0	-2.5	277.5	7.2	7.0	-2.5	202.5	45.2	1.0
-2.5	197.5	37.0	5.0	-2.5	187.5	-4.2	3.0	-2.5	182.5	15.5	3.0	-2.5	177.5	-0.6	11.0
-2.5	157.5	32.5	7.0	-2.5	152.5	25.7	15.0	-2.5	147.5	44.9	24.0	-2.5	142.5	29.0	23.0
-2.5	137.5	5.8	11.0	-2.5	132.5	25.0	16.0	-2.5	127.5	11.8	21.0	-2.5	122.5	-1.4	14.0
-2.5	117.5	9.8	12.0	-2.5	112.5	41.8	3.0	-2.5	107.5	37.9	16.0	-2.5	102.5	4.3	10.0
-2.5	97.5	9.1	15.0	-2.5	92.5	-17.0	11.0	-2.5	87.5	-31.1	16.0	-2.5	82.5	-30.6	20.0
-2.5	77.5	-47.2	9.0	-2.5	72.5	-41.7	14.0	-2.5	67.5	-29.0	8.0	-2.5	62.5	-17.8	17.0
-2.5	57.5	-10.9	23.0	-2.5	52.5	-7.3	20.0	-2.5	47.5	-19.6	12.0	-2.5	42.5	-29.4	18.0
-2.5	37.5	20.0	16.0	-2.5	32.5	-2.0	23.0	-2.5	27.5	6.9	20.0	-2.5	22.5	-33.6	25.0
-2.5	17.5	-18.7	18.0	-2.5	12.5	-8.0	6.0	-2.5	7.5	72.2	1.0	-7.5	357.5	-3.7	3.0
-7.5	352.5	-2.5	2.0	-7.5	347.5	9.2	18.0	-7.5	342.5	1.1	18.0	-7.5	337.5	-2.8	8.0
-7.5	332.5	-10.0	3.0	-7.5	327.5	-14.4	11.0	-7.5	322.5	4.4	25.0	-7.5	317.5	-21.8	29.0
-7.5	312.5	-25.7	22.0	-7.5	297.5	12.0	1.0	-7.5	292.5	21.5	2.0	-7.5	287.5	-9.6	7.0
-7.5	282.5	-20.8	4.0	-7.5	277.5	-4.8	5.0	-7.5	217.5	50.0	1.0	-7.5	202.5	3.0	1.0
-7.5	197.5	51.4	5.0	-7.5	192.5	7.0	2.0	-7.5	187.5	-1.0	4.0	-7.5	182.5	-4.2	5.0
-7.5	177.5	4.7	9.0	-7.5	172.5	1.7	9.0	-7.5	167.5	-43.0	1.0	-7.5	162.5	70.0	5.0
-7.5	157.5	90.5	18.0	-7.5	152.5	26.9	22.0	-7.5	147.5	5.1	24.0	-7.5	142.5	42.0	25.0
-7.5	137.5	18.0	14.0	-7.5	132.5	-23.9	19.0	-7.5	127.5	-12.1	25.0	-7.5	122.5	-3.1	21.0
-7.5	117.5	18.4	20.0	-7.5	112.5	19.1	20.0	-7.5	107.5	14.6	24.0	-7.5	102.5	-16.5	19.0
-7.5	97.5	17.6	8.0	-7.5	92.5	-20.4	3.0	-7.5	87.5	-42.0	1.0	-7.5	82.5	-33.2	7.0
-7.5	72.5	-13.4	8.0	-7.5	57.5	-0.2	11.0	-7.5	62.5	-10.4	5.0	-7.5	57.5	1.9	10.0
-7.5	52.5	-4.9	8.0	-7.5	47.5	-15.8	15.0	-7.5	42.5	-33.4	13.0	-7.5	37.5	8.9	20.0
-7.5	32.5	10.3	23.0	-7.5	27.5	-5.3	21.0	-7.5	22.5	-13.0	12.0	-7.5	17.5	-12.0	2.0
-7.5	12.5	36.3	3.0	-7.5	7.5	-5.3	4.0	-12.5	357.5	-0.9	2.0	-12.5	352.5	-9.8	3.0
-12.5	347.5	-1.3	12.0	-12.5	342.5	-3.4	5.0	-12.5	327.5	-5.4	8.0	-12.5	322.5	-1.1	16.0
-12.5	317.5	-2.3	25.0	-12.5	312.5	10.6	20.0	-12.5	307.5	-88.4	1.0	-12.5	297.5	63.0	2.0
-12.5	292.5	29.0	7.0	-12.5	287.5	27.5	4.0	-12.5	282.5	-0.0	9.0	-12.5	277.5	-0.4	1.0
-12.5	197.5	27.0	6.0	-12.5	192.5	28.5	8.0	-12.5	187.5	25.2	6.0	-12.5	182.5	29.5	7.0
-12.5	177.5	2.9	5.0	-12.5	172.5	-32.4	1.0	-12.5	167.5	23.7	18.0	-12.5	162.5	69.7	11.0
-12.5	157.5	29.0	9.0	-12.5	152.5	43.3	16.0	-12.5	147.5	10.1	21.0	-12.5	142.5	22.9	23.0
-12.5	137.5	21.5	22.0	-12.5	132.5	34.8	21.0	-12.5	127.5	15.3	22.0	-12.5	122.5	3.3	21.0
-12.5	117.5	-15.3	22.0	-12.5	112.5	-11.1	18.0	-12.5	107.5	4.9	13.0	-12.5	102.5	-3.0	15.0
-12.5	97.5	-3.4	12.0	-12.5	92.5	-20.6	10.0	-12.5	87.5	1.5	1.0	-12.5	82.5	-25.6	6.0
-12.5	72.5	19.5	1.0	-12.5	57.5	6.2	8.0	-12.5	62.5	-5.9	7.0	-12.5	57.5	-11.3	8.0
-12.5	52.5	-3.8	12.0	-12.5	47.5	22.0	8.0	-12.5	42.5	-23.7	14.0	-12.5	37.5	-11.3	9.0
-12.5	32.5	-3.5	11.0	-12.5	27.5	-7.0	12.0	-12.5	22.5	6.5	2.0	-12.5	17.5	25.3	1.0
-12.5	12.5	22.0	2.0	-17.5	357.5	5.5	5.0	-17.5	327.5	-18.3	5.0	-17.5	322.5	-11.5	10.0
-17.5	317.5	-17.7	25.0	-17.5	312.5	-17.6	23.0	-17.5	307.5	-15.1	1.0	-17.5	302.5	23.1	7.0
-17.5	297.5	22.3	11.0	-17.5	292.5	85.9	15.0	-17.5	287.5	11.1	9.0	-17.5	282.5	-51.1	1.0
-17.5	272.5	7.9	1.0	-17.5	217.5	7.9	1.0	-17.5	212.5	89.9	1.0	-17.5	207.5	104.9	1.0
-17.5	202.5	54.9	1.0	-17.5	192.5	87.9	2.0	-17.5	187.5	-10.9	5.0	-17.5	192.5	-1.7	3.0
-17.5	177.5	38.7	10.0	-17.5	172.5	40.9	3.0	-17.5	167.5	39.1	9.0	-17.5	162.5	2.3	3.0
-17.5	157.5	17.4	9.0	-17.5	152.5	53.9	1.0	-17.5	147.5	23.7	17.0	-17.5	142.5	19.1	25.0
-17.5	137.5	13.2	24.0	-17.5	132.5	7.6	25.0	-17.5	127.5	25.3	18.0	-17.5	122.5	20.4	19.0
-17.5	117.5	4.3	17.0	-17.5	112.5	-20.9	10.0	-17.5	107.5	-15.6	6.0	-17.5	102.5	-29.7	8.0
-17.5	97.5	-20.1	12.0	-17.5	92.5	-27.7	13.0	-17.5	87.5	-10.3	12.0	-17.5	82.5	-21.1	12.0
-17.5	77.5	16.8	7.0	-17.5	57.5	5.6	6.0	-17.5	62.5	19.6	12.0	-17.5	57.5	10.8	15.0

Table A-1 (continued)

PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N
-17.5	52.5	4.9	8.0	-17.5	47.5	22.3	22.0	-17.5	42.5	-10.2	14.0	-17.5	37.5	4.3	5.0
-17.5	32.5	7.2	15.0	-17.5	27.5	5.7	9.0	-17.5	22.5	2.4	4.0	-17.5	17.5	26.9	1.0
-17.5	12.5	18.9	2.0	-17.5	7.5	18.4	2.0	-22.5	357.5	14.2	1.0	-22.5	327.5	-24.0	5.0
-22.5	322.5	-20.8	5.0	-22.5	317.5	2.2	16.0	-22.5	312.5	-7.3	20.0	-22.5	307.5	-13.4	19.0
-22.5	302.5	12.2	2.0	-22.5	297.5	10.6	12.0	-22.5	292.5	77.0	16.0	-22.5	287.5	5.7	8.0
-22.5	247.5	8.2	1.0	-22.5	242.5	13.5	7.0	-22.5	192.5	-27.1	4.0	-22.5	187.5	-18.8	4.0
-22.5	182.5	50.8	5.0	-22.5	177.5	57.2	1.0	-22.5	172.5	37.4	8.0	-22.5	167.5	79.5	8.0
-22.5	162.5	46.2	4.0	-22.5	157.5	7.5	6.0	-22.5	152.5	32.0	7.0	-22.5	147.5	27.7	17.0
-22.5	142.5	7.5	17.0	-22.5	137.5	17.8	13.0	-22.5	132.5	6.1	13.0	-22.5	127.5	-6.1	18.0
-22.5	122.5	5.5	23.0	-22.5	117.5	7.5	14.0	-22.5	112.5	-6.0	13.0	-22.5	102.5	-27.0	5.0
-22.5	97.5	-35.1	8.0	-22.5	92.5	-25.2	5.0	-22.5	87.5	-18.8	5.0	-22.5	82.5	-6.2	3.0
-22.5	77.5	1.4	8.0	-22.5	72.5	22.9	15.0	-22.5	67.5	30.0	15.0	-22.5	62.5	31.4	15.0
-22.5	57.5	11.1	22.0	-22.5	52.5	9.5	10.0	-22.5	47.5	30.7	15.0	-22.5	42.5	5.6	23.0
-22.5	37.5	-8.3	8.0	-22.5	32.5	-6.7	12.0	-22.5	27.5	16.4	16.0	-22.5	22.5	8.7	4.0
-22.5	17.5	26.9	7.0	-22.5	12.5	1.5	3.0	-22.5	7.5	-0.8	1.0	-22.5	2.5	8.8	8.0
-27.5	352.5	-15.8	1.0	-27.5	322.5	-6.9	6.0	-27.5	317.5	-34.3	2.0	-27.5	312.5	-13.3	18.0
-27.5	307.5	3.9	20.0	-27.5	302.5	15.7	12.0	-27.5	297.5	12.4	24.0	-27.5	292.5	61.8	25.0
-27.5	287.5	46.7	8.0	-27.5	252.5	5.1	7.0	-27.5	247.5	3.2	6.0	-27.5	192.5	-12.1	3.0
-27.5	187.5	-10.1	6.0	-27.5	182.5	52.9	6.0	-27.5	177.5	4.9	3.0	-27.5	172.5	29.2	1.0
-27.5	167.5	32.6	3.0	-27.5	162.5	18.7	4.0	-27.5	157.5	4.2	3.0	-27.5	152.5	24.9	22.0
-27.5	147.5	9.2	25.0	-27.5	142.5	-3.0	25.0	-27.5	137.5	-5.4	24.0	-27.5	132.5	-25.6	21.0
-27.5	127.5	-1.1	19.0	-27.5	122.5	0.0	9.0	-27.5	117.5	6.5	14.0	-27.5	112.5	-6.3	8.0
-27.5	107.5	-33.4	10.0	-27.5	102.5	2.5	6.0	-27.5	97.5	-15.8	3.0	-27.5	92.5	-8.8	5.0
-27.5	87.5	3.6	5.0	-27.5	82.5	-11.2	5.0	-27.5	72.5	41.2	3.0	-27.5	67.5	36.4	6.0
-27.5	62.5	11.2	6.0	-27.5	57.5	0.8	7.0	-27.5	52.5	7.1	11.0	-27.5	47.5	24.7	13.0
-27.5	42.5	16.6	11.0	-27.5	37.5	-11.1	12.0	-27.5	32.5	26.1	16.0	-27.5	27.5	38.3	25.0
-27.5	22.5	18.3	22.0	-27.5	17.5	27.4	23.0	-27.5	12.5	-11.8	2.0	-27.5	7.5	5.5	9.0
-27.5	2.5	1.2	1.0	-32.5	357.5	29.2	3.0	-32.5	352.5	-3.1	3.0	-32.5	337.5	30.2	1.0
-32.5	332.5	14.2	3.0	-32.5	327.5	-30.8	2.0	-32.5	322.5	3.0	4.0	-32.5	317.5	12.2	5.0
-32.5	312.5	14.5	3.0	-32.5	307.5	20.1	15.0	-32.5	302.5	21.8	24.0	-32.5	297.5	18.5	25.0
-32.5	292.5	7.9	25.0	-32.5	287.5	48.9	10.0	-32.5	282.5	-13.8	1.0	-32.5	277.5	10.0	5.0
-32.5	272.5	1.4	5.0	-32.5	267.5	-0.8	5.0	-32.5	262.5	-71.8	1.0	-32.5	257.5	-3.9	7.0
-32.5	252.5	-5.1	3.0	-32.5	247.5	1.2	4.0	-32.5	242.5	10.0	4.0	-32.5	237.5	6.2	5.0
-32.5	232.5	17.5	3.0	-32.5	227.5	-38.2	5.0	-32.5	222.5	-125.0	5.0	-32.5	217.5	20.9	3.0
-32.5	212.5	3.7	2.0	-32.5	192.5	-18.8	5.0	-32.5	187.5	-17.8	2.0	-32.5	182.5	-23.8	6.0
-32.5	177.5	106.2	1.0	-32.5	172.5	82.2	2.0	-32.5	157.5	4.9	3.0	-32.5	152.5	19.5	18.0
-32.5	147.5	15.8	20.0	-32.5	142.5	-1.7	24.0	-32.5	137.5	5.9	25.0	-32.5	132.5	-22.2	13.0
-32.5	127.5	-17.4	10.0	-32.5	122.5	-14.5	21.0	-32.5	117.5	-1.0	23.0	-32.5	112.5	-40.2	11.0
-32.5	107.5	-36.3	12.0	-32.5	102.5	-27.5	6.0	-32.5	97.5	-21.8	8.0	-32.5	92.5	19.7	2.0
-32.5	72.5	36.6	5.0	-32.5	52.5	-5.5	6.0	-32.5	47.5	39.6	3.0	-32.5	42.5	75.2	3.0
-32.5	37.5	-1.7	10.0	-32.5	32.5	21.9	11.0	-32.5	27.5	19.1	22.0	-32.5	22.5	27.5	25.0
-32.5	17.5	13.2	20.0	-32.5	12.5	4.2	13.0	-32.5	7.5	16.7	2.0	-32.5	2.5	23.2	1.0
-37.5	347.5	21.1	3.0	-37.5	342.5	18.1	1.0	-37.5	337.5	31.1	1.0	-37.5	317.5	-10.3	3.0
-37.5	312.5	-20.3	3.0	-37.5	307.5	5.3	8.0	-37.5	302.5	21.0	20.0	-37.5	297.5	9.4	23.0
-37.5	292.5	11.2	25.0	-37.5	287.5	40.7	17.0	-37.5	282.5	9.1	1.0	-37.5	267.5	1.1	1.0
-37.5	262.5	-5.4	9.0	-37.5	257.5	-6.9	1.0	-37.5	247.5	-43.9	1.0	-37.5	242.5	2.1	1.0
-37.5	237.5	11.3	4.0	-37.5	232.5	12.1	3.0	-37.5	227.5	-168.9	3.0	-37.5	222.5	-141.2	6.0
-37.5	217.5	-51.3	3.0	-37.5	192.5	-34.3	3.0	-37.5	187.5	-34.1	5.0	-37.5	182.5	-4.4	4.0
-37.5	177.5	18.5	18.0	-37.5	172.5	30.9	10.0	-37.5	167.5	17.1	3.0	-37.5	162.5	0.7	5.0
-37.5	157.5	-7.1	6.0	-37.5	152.5	15.8	3.0	-37.5	147.5	21.4	18.0	-37.5	142.5	8.6	16.0
-37.5	137.5	5.9	7.0	-37.5	107.5	-47.4	2.0	-37.5	102.5	-26.8	6.0	-37.5	97.5	-11.5	5.0
-37.5	92.5	-5.1	7.0	-37.5	87.5	6.6	6.0	-37.5	82.5	-10.6	6.0	-37.5	77.5	-0.6	11.0

Table A-1 (continued)

PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N
-37.5	72.5	0.1	3.0	-37.5	52.5	3.1	4.0	-37.5	42.5	33.1	4.0	-37.5	37.5	13.3	6.0
-37.5	32.5	18.5	8.0	-37.5	27.5	6.9	14.0	-37.5	22.5	7.0	11.0	-37.5	12.5	5.6	2.0
-37.5	7.5	-7.6	3.0	-42.5	357.5	-38.1	1.0	-42.5	312.5	-16.1	6.0	-42.5	307.5	-2.8	10.0
-42.5	302.5	-17.3	12.0	-42.5	297.5	-8.5	5.0	-42.5	292.5	32.7	20.0	-42.5	287.5	41.7	15.0
-42.5	282.5	3.2	3.0	-42.5	272.5	-4.9	3.0	-42.5	267.5	-1.8	8.0	-42.5	192.5	-34.4	3.0
-42.5	187.5	-37.8	6.0	-42.5	182.5	9.8	7.0	-42.5	177.5	18.8	8.0	-42.5	172.5	13.1	16.0
-42.5	167.5	21.4	4.0	-42.5	157.5	-10.5	5.0	-42.5	147.5	32.0	3.0	-42.5	72.5	-2.9	5.0
-47.5	307.5	-0.8	6.0	-47.5	302.5	-9.5	16.0	-47.5	297.5	-5.5	4.0	-47.5	292.5	-1.1	14.0
-47.5	287.5	-9.9	5.0	-47.5	282.5	-68.3	1.0	-47.5	277.5	17.9	6.0	-47.5	272.5	17.5	5.0
-47.5	192.5	4.7	1.0	-47.5	187.5	-23.6	14.0	-47.5	182.5	-5.0	4.0	-47.5	172.5	38.7	3.0
-47.5	167.5	77.1	8.0	-47.5	157.5	-14.5	5.0	-47.5	72.5	26.5	4.0	-47.5	67.5	70.7	1.0
-52.5	322.5	77.2	3.0	-52.5	302.5	-5.3	16.0	-52.5	297.5	12.6	14.0	-52.5	292.5	14.2	8.0
-52.5	287.5	-3.5	3.0	-52.5	282.5	7.0	7.0	-52.5	277.5	23.9	3.0	-52.5	192.5	-5.5	5.0
-52.5	187.5	1.5	1.0	-52.5	167.5	34.5	2.0	-52.5	137.5	-14.3	5.0	-52.5	72.5	47.5	1.0
-52.5	67.5	20.5	4.0	-57.5	332.5	46.4	4.0	-57.5	327.5	47.4	1.0	-57.5	317.5	13.4	2.0
-57.5	312.5	23.3	9.0	-57.5	307.5	17.9	13.0	-57.5	302.5	28.6	5.0	-57.5	297.5	53.4	1.0
-57.5	292.5	44.6	6.0	-57.5	287.5	-11.8	5.0	-57.5	192.5	-36.8	3.0	-57.5	187.5	-18.0	5.0
-62.5	317.5	24.4	1.0	-52.5	312.5	63.6	5.0	-62.5	307.5	41.0	7.0	-62.5	302.5	48.4	14.0
-62.5	297.5	42.2	10.0	-62.5	192.5	-18.3	4.0	-62.5	187.5	11.9	2.0	-62.5	162.5	-8.6	1.0
-62.5	157.5	4.4	7.0	-62.5	152.5	-11.1	4.0	-67.5	297.5	40.0	2.0	-67.5	292.5	33.5	7.0
-67.5	272.5	17.5	1.0	-57.5	192.5	-6.5	2.0	-67.5	187.5	-6.2	10.0	-67.5	182.5	-13.6	7.0
-67.5	177.5	2.7	6.0	-67.5	172.5	-5.9	5.0	-67.5	167.5	-6.3	6.0	-67.5	162.5	-12.2	9.0
-67.5	142.5	0.8	3.0	-67.5	137.5	57.5	4.0	-67.5	132.5	-15.5	1.0	-67.5	122.5	28.5	1.0
-67.5	112.5	22.1	16.0	-57.5	102.5	20.0	2.0	-67.5	97.5	48.7	4.0	-67.5	92.5	30.4	10.0
-67.5	87.5	28.8	3.0	-57.5	82.5	10.5	2.0	-67.5	77.5	47.5	2.0	-67.5	72.5	31.5	2.0
-67.5	62.5	37.2	3.0	-67.5	57.5	54.2	3.0	-67.5	52.5	87.5	1.0	-67.5	42.5	49.5	1.0
-67.5	37.5	36.8	7.0	-57.5	32.5	51.5	2.0	-72.5	292.5	49.7	9.0	-72.5	287.5	54.1	5.0
-72.5	282.5	14.3	5.0	-72.5	277.5	11.1	5.0	-72.5	272.5	21.2	5.0	-72.5	267.5	26.9	5.0
-72.5	262.5	-10.3	1.0	-72.5	242.5	-55.9	2.0	-72.5	212.5	-47.3	1.0	-72.5	207.5	-28.7	5.0
-72.5	172.5	-41.3	1.0	-72.5	162.5	14.2	2.0	-72.5	157.5	-26.3	5.0	-72.5	152.5	-28.7	5.0
-72.5	147.5	-21.7	7.0	-72.5	142.5	-15.0	10.0	-72.5	137.5	-27.3	2.0	-72.5	112.5	-51.1	7.0
-72.5	107.5	-32.3	1.0	-72.5	97.5	9.7	11.0	-72.5	92.5	25.3	7.0	-72.5	87.5	11.9	6.0
-72.5	27.5	23.7	1.0	-72.5	22.5	13.3	7.0	-77.5	332.5	21.1	1.0	-77.5	327.5	-6.9	1.0
-77.5	322.5	-25.0	7.0	-77.5	317.5	-19.5	8.0	-77.5	312.5	24.1	1.0	-77.5	297.5	1.1	1.0
-77.5	292.5	11.4	7.0	-77.5	287.5	17.3	5.0	-77.5	282.5	-23.2	3.0	-77.5	277.5	-9.2	3.0
-77.5	272.5	15.4	13.0	-77.5	267.5	9.9	21.0	-77.5	262.5	-19.4	14.0	-77.5	257.5	-17.2	16.0
-77.5	252.5	-29.4	12.0	-77.5	247.5	-19.3	14.0	-77.5	242.5	-3.1	15.0	-77.5	237.5	4.3	13.0
-77.5	232.5	12.2	10.0	-77.5	227.5	-10.0	12.0	-77.5	222.5	-18.2	11.0	-77.5	217.5	-34.4	7.0
-77.5	212.5	-1.9	6.0	-77.5	207.5	-28.3	5.0	-77.5	202.5	-15.5	6.0	-77.5	197.5	-34.3	5.0
-77.5	192.5	-23.3	9.0	-77.5	187.5	-16.3	9.0	-77.5	182.5	-17.0	8.0	-77.5	172.5	-16.9	2.0
-77.5	167.5	-13.4	12.0	-77.5	162.5	-45.9	15.0	-77.5	157.5	30.4	8.0	-77.5	152.5	-39.0	10.0
-77.5	147.5	-51.5	10.0	-77.5	142.5	-44.4	10.0	-77.5	137.5	-32.7	7.0	-77.5	132.5	-4.9	4.0
-77.5	107.5	-6.0	8.0	-77.5	102.5	-57.2	6.0	-77.5	97.5	0.1	2.0	-77.5	92.5	18.5	5.0
-77.5	87.5	24.6	4.0	-77.5	82.5	44.5	5.0	-77.5	77.5	36.6	2.0	-82.5	312.5	-30.8	6.0
-82.5	307.5	-22.4	6.0	-82.5	302.5	-35.9	10.0	-82.5	297.5	-8.1	5.0	-82.5	292.5	22.3	5.0
-82.5	287.5	-8.0	16.0	-82.5	282.5	-10.3	10.0	-82.5	277.5	-15.3	11.0	-82.5	272.5	3.8	11.0
-82.5	267.5	11.3	14.0	-82.5	252.5	15.2	24.0	-82.5	257.5	11.5	24.0	-82.5	252.5	-5.8	24.0
-82.5	247.5	-43.8	16.0	-82.5	242.5	-10.6	16.0	-82.5	237.5	-29.3	12.0	-82.5	232.5	-8.3	4.0
-82.5	227.5	-21.3	3.0	-82.5	222.5	-10.3	1.0	-82.5	197.5	-20.5	4.0	-82.5	192.5	-22.3	11.0
-82.5	187.5	-25.2	11.0	-82.5	182.5	-24.3	5.0	-82.5	177.5	-11.3	2.0	-82.5	172.5	-24.9	8.0
-82.5	167.5	-37.5	8.0	-82.5	162.5	-42.3	2.0	-82.5	157.5	-43.6	3.0	-82.5	137.5	-22.0	9.0
-82.5	132.5	-28.0	12.0	-82.5	127.5	-38.6	9.0	-82.5	122.5	-26.3	1.0	-82.5	77.5	88.2	4.0

Table A-1 (continued)

PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N	PHI	LAMDA	DEL G	N
-82.5	72.5	53.7	3.0	-82.5	57.5	29.0	4.0	-82.5	52.5	32.7	3.0	-82.5	57.5	51.7	2.0
-82.5	52.5	47.7	2.0	-87.5	347.5	-32.2	4.0	-87.5	342.5	-23.5	1.0	-87.5	337.5	-25.5	1.0
-87.5	332.5	-30.5	2.0	-87.5	327.5	-35.5	2.0	-87.5	322.5	-39.8	3.0	-87.5	317.5	-49.1	3.0
-87.5	312.5	-30.1	5.0	-87.5	307.5	-23.9	5.0	-87.5	302.5	1.8	4.0	-87.5	297.5	4.9	3.0
-87.5	292.5	10.2	3.0	-87.5	287.5	9.9	3.0	-87.5	282.5	-1.1	3.0	-87.5	277.5	-10.5	3.0
-87.5	272.5	-39.5	5.0	-87.5	257.5	-32.7	4.0	-87.5	262.5	-32.5	1.0	-87.5	257.5	-31.5	1.0
-87.5	252.5	-22.5	1.0	-87.5	247.5	-8.5	8.0	-87.5	242.5	26.0	4.0	-87.5	237.5	-12.8	6.0
-87.5	232.5	-14.8	6.0	-87.5	227.5	27.2	3.0	-87.5	222.5	-7.1	3.0	-87.5	217.5	-10.3	7.0
-87.5	212.5	22.9	6.0	-87.5	207.5	9.5	5.0	-87.5	202.5	-3.1	6.0	-87.5	197.5	-53.5	1.0
-87.5	167.5	-4.0	4.0	-87.5	162.5	-23.7	10.0	-87.5	157.5	-22.8	11.0	-87.5	152.5	-20.7	8.0
-87.5	147.5	-17.5	7.0	-87.5	142.5	-19.1	5.0	-87.5	137.5	-16.0	2.0				

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